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DEFINING AND ASSESSING THE IMPACT TO THE COMBAT/WEAPON SYSTEMS OF A SHIP POST MAJOR OVERHAUL

by

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June 2013

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This thesis develops a quantitative process for determining if the changes being made to the combat/weapon systems during a maintenance availability are significant and the risk those changes pose to the readiness of the ship. The purpose of this process is to assist decision-makers in determining if a ship should conduct Combat Systems Ship Qualification Trials (CSSQT) post-availability. The process uses warfare area criticality and type of change to determine the significance of the change. Risk is assessed by determining the likelihood the changes will impact maintenance readiness, operational readiness and safety. The final result of the process is a matrix that uses the significance and risk likelihood values to graphically represent the overall impact the availability has on the ship. Where a ship is plotted on the matrix will determine the recommendation for that ship.

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DEFINING AND ASSESSING THE IMPACT TO THE COMBAT/WEAPON SYSTEMS OF A SHIP POST MAJOR OVERHAUL

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This thesis develops a quantitative process for determining if the changes being made to the combat/weapon systems during a maintenance availability are significant and the risk those changes pose to the readiness of the ship. The purpose of this process is to assist decision-makers in determining if a ship should conduct Combat Systems Ship Qualification Trials (CSSQT) post-availability. The process uses warfare area criticality and type of change to determine the significance of the change. Risk is assessed by determining the likelihood the changes will impact maintenance readiness, operational readiness and safety. The final result of the process is a matrix that uses the significance and risk likelihood values to graphically represent the overall impact the availability has on the ship. Where a ship is plotted on the matrix will determine the recommendation for that ship.

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LIST OF ACRONYMS AND ABBREVIATIONS

ARB	Annual Review Board
CSSQT	Combat Systems Ship Qualification Trials
ILS	Integrated Logistics Systems
NAVSEA	Naval Sea Systems Command
NMP	Navy Modernization Plan
NSWC	Naval Surface Warfare Center
OSS	Operational Sequencing System
PEO	Program Executive Officer
PHD	Port Hueneme Division
PM	Program Manager
PMS	Planned Maintenance System
SCD	Ship Change Document
SEB	System Engineering Board
SME	Subject Manner Expert
TYCOM	Type Commander
WISE	Warfare Interface System Engineering
WSID	Warfare System Interface Diagram

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EXECUTIVE SUMMARY

This thesis develops a process for quantifying the impact a major overhaul/modernization has on a ship's overall readiness in terms of the significance of changes and the likelihood of risk. The need for such a process is because there is not a quantitative process in place for designating a ship for Combat Systems Ship Qualification Trials (CSSQT). The Naval Surface Warfare Center Port Hueneme Division (NSWC PHD) created a process and this thesis investigates that process and develops a methodology to determine the impact to ship's readiness that builds from the current work. The result is a tool for determining the significance of the maintenance availability, a tool for assessing the likelihood of risk, and a process for presenting the results in a manner that allows decision-makers to easily determine if a ship should be designated to conduct a CSSQT based on the overall impact to ship's readiness.

The governing instruction for CSSQT, NAVSEAINST 9093.1C, states that a ship will be designated for a CSSQT if it is undergoing a *significant* overhaul/modernization availability. The instruction does not describe what constitutes significant; therefore, the first step is to make a decision about designating a ship for CSSQT is to determine if the availability is significant. NSWC PHD designed a procedure for determining significance and called it the CSSQT Decision Tool. A functional decomposition was used to review the tool and the following problems were discovered:

- *The name of the tool does not accurately reflect the purpose of the tool.* This is a minor issue but it is important that the name of the tool describes the intended purpose. The current tool is called the CSSQT Decision Tool which indicates the purpose of the tool is to make a decision. The review determined that the actual purpose of the tool is to assess the significance of changes being made to the combat/weapon systems. To better reflect the purpose of the tool the name has been changed to Significance Assessment tool
- *There is an inaccurate accountability of all combat/weapon systems.* Ten ships were assessed using NSWC PHD's process and the review of the assessments found a majority of the ships had an inaccurate accountability of the combat/weapon systems onboard the ship. The assessments were missing systems, had the wrong systems listed and grouped training systems together. The training systems were grouped because they were

not critical to any warfare area and therefore any changes made to those systems did not need to be accounted for. Training systems are a major part of the crew's readiness and need to be assessed individually in the same manner as the other systems. To achieve an accurate assessment, careful attention to include the correct systems must occur.

- *The significance calculation result is ambiguous.* The result of the process is a percentage, but it is unclear what the value is a percentage of. The best approach for showing significance is to use an interval scale where a significance of 10 is extremely significant and a significance of 0 is not significant.
- *The significance calculation does not account for non-critical systems.* Systems not critical to a warfare area are not accounted for in the assessment, even if the system is being altered. CSSQT validates and verifies all combat/weapon systems, so it is important every system is included in the assessment. A weight is given to non-critical systems and added to the function to determine significance.
- *A completed assessment can result in a spreadsheet that contains empty cells and cells that contain FALSE as an entry.* Systems not being changed are left blank on the assessment spreadsheet which leads to invalid calculations and cells that contain FALSE. This practice makes the assessment look incomplete. To solve this, a category was added to indicate that a system is not being changed during the availability

The likelihood of risk to a ship's readiness can be used as an indicator of how the maintenance availability impacts a ship. This thesis developed a method for determining the likelihood a ship's readiness will be impacted by the changes being made to the combat/weapon systems. The risk assessment tool developed by NSWC PHD was compared to the new methodology and the following issues were discovered:

- *The risk areas and risk factors do not align with the objectives outlined in NAVSEAINST 9093.1C.* The risk areas proposed by NSWC PHD are Effectiveness, Readiness, Safety and Personnel but the instruction specifically states that the objectives of CSSQT are: "To ensure a ship's combat system has a high level of operational readiness, maintenance readiness, and is safe" (NAVSEA 2006). The instruction also outlines the factors that are assessed to ensure the objectives are met. Aligning the risk assessment with the instruction ensures the assessment fully captures the intent of CSSQT.
- *A large number of risk factors required subjective input from outside sources.* The risk assessment is intended to be quantitative, not qualitative, and the proposed process uses subjective assessments to determine risk. The assessment must be consistent for each ship being evaluated to ensure

the results are consistent. Relying on subjective assessment can lead to inconsistencies and can also make completing the assessment difficult. All subjectivity has been removed from the risk assessment and it relies only on data that can be found in on-line databases.

- *The output of the assessment is ambiguous.* The result of the assessment is in the form of a percentage, but it is unclear what this percentage represents. The same scale that is used in the Significance Assessment will be used for the risk assessment, where 10 is extremely likely and 0 is not likely.

The final result is a process that uses the significance assessment and risk assessment to determine the overall impact to a ship's readiness. To accomplish this, a central spreadsheet for the results of the assessments was created. This is called the CSSQT Determination Dashboard. It collects the results from the assessments and determines a score for the significance and risk likelihood. These scores are plotted on the Determination Matrix, shown in Figure 1, for each ship being assessed. The plot provides a graphical view of the results and the quadrants of the matrix are labeled to give a recommendation based on the significance and likelihood.

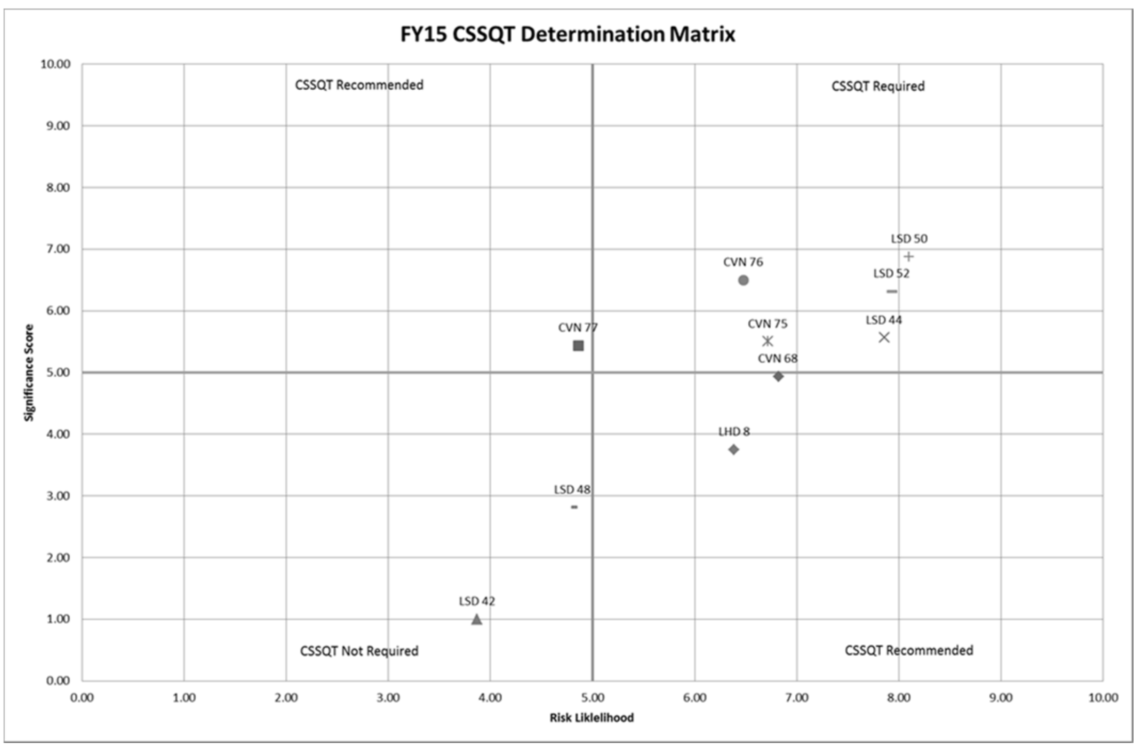

Figure 1. CSSQT Determination Matrix

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I could not have done this without the love and support of my amazing wife.

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I. INTRODUCTION

This thesis will investigate and determine a quantitative procedure to assess the overall impact to a ship's operational readiness after a major modernization. The procedure is required as part of a new systematic process for designating a ship to conduct Combat System Ship Qualification Trials (CSSQT). Naval Sea Systems Command, Port Hueneme Division (NSWC PHD) determined that there is a "*Lack of an objective and validated process to determine CSSQTs*," there is an "*Inability to predict risk for post availability impacts 3 to 4 years in advance*," and there are "*Multiple interpretations of 'significant'*" (B. Hazel and S. Matthews, unpublished Powerpoint slide). In 2012, NSWC PHD introduced a new process for determining which ships should be designated for CSSQT and the process includes a tool for assessing the significance and a tool for assessing the risk. This thesis will present a methodology to review the two tools and present a new procedure for assessing overall impact to a ship's readiness.

A. PROBLEM STATEMENT

According to NAVSEAINST 9093.1C, "CSSQTs will be scheduled for all surface combatants, aircraft carriers, and amphibious ships completing new construction or significant conversion/modernization availabilities" (2006). The problem is how to define a significant conversion/modernization. Prior to 2012, it was the responsibility of the "applicable Program Executive Offices (PEOs)/Program Managers (PMs) in coordination with the Type Commanders, CSSQT Certification Authority and Naval Sea Systems Command (SEA 62) to designate a ship for CSSQT post-availability" (NAVSEA 2006) based on subjective assessment and the availability of funding. NSWC PHD (CSSQT Certification Authority) has determined the need for a process that removes subjectivity and relies on a quantitative assessment to determine the significance of combat/weapon system changes made during a maintenance availability in order to make a decision if a CSSQT is warranted for a specific ship. Furthermore, NSWC PHD deemed it necessary to assess the risk associated with the significance of the conversion/modernization. An assessment of the significance and the risk to the ship will give decision-makers the information to fully understand the nature of the modernization and make a better decision when designating a ship for CSSQT. A procedure that can be applied to all ships scheduled for a conversion/modernization needs to be designed that will assess the significance and risk the conversion/modernization will have on the ship's readiness.

B. SCOPE

CSSQT is performed on every class of surface combatant ships and it is necessary to assess each ship undergoing a conversion/modernization, but this research will restrict the assessment to amphibious ships and aircraft carriers. The research will analyze ships conducting a maintenance availability in fiscal year 2015. The focus will be on reviewing the tools created by NSWC PHD and developing an objective process for determining the significance and risk associated with a major conversion/modernization.

C. ORGANIZATION

The next chapter will discuss the background of CSSQT and present the current work being done by NSWC PHD. The third chapter describes the methodology used to review the current work and the process used to develop the new risk and significance tools. The fourth chapter will present the results of the methodology. The final chapter will discuss conclusions and recommendations for further research.

II. BACKGROUND

A. COMBAT SYSTEMS SHIP QUALIFICATION TRIALS

CSSQT is a major evolution that requires years of planning and two to three months to execute depending on the complexity of the combat systems on the individual ship. The execution of a CSSQT is governed by *NAVSEA Instruction 9093.1C*, *Combat System Ship Qualification Trials for Surface Ships*. The instruction outlines the purpose, policy, objectives, definitions, guidelines and the planning process for any surface ship designated to conduct a CSSQT. Purpose and policy are important to understanding why CSSQTs are conducted and what is required to designate a ship to perform one. They also provide valuable information on how to approach creating a process for making a recommendation a ship conduct a CSSQT. The purpose of CSSQT is:

> To verify and validate that an individual ship's combat/weapon systems have been installed correctly and can be operated and maintained in a safe and effective manner. This is accomplished by assisting ship's force in achieving (1) a sustainable level of combat/weapon system operational readiness and (2) a maintainable level of material readiness. (NAVSEA 2006)

The purpose indicates after a successful completion of CSSQT the ship will be able to operate and maintain the combat/weapon systems at a higher level than if it had not conducted a CSSQT. It can be inferred a ship should conduct a CSSQT if there are circumstance that reduce the ship's ability to operate and maintain the combat/weapon systems. The policy of CSSQT provides the circumstances and gives guidance to when a ship should conduct a CSSQT.

> CSSQTs will be scheduled for all surface combatants, aircraft carriers, and amphibious ships completing new construction or significant conversion/modernization availabilities. Designation of post availability ships for CSSQTs will be made by applicable Program Executive Offices (PEOs)/Program Managers (PMs) in coordination with the Type Commanders, CSSQT Certification Authority and Naval Sea Systems Command (SEA 62). These designations will be based on the extent of combat system changes made during the availability or the cumulative effect of combat/weapon systems changes since the last CSSQT. Determinations to conduct CSSQTs and their scope will be developed by a

> collaborative system engineering process. Following CSSQT, each applicable mission area will be qualified to be safe and effective based on combat/weapon system performance and observed crew proficiency. (NAVSEA 2006)

A ship is designated to execute a CSSQT at an annual review board conducted by SEA 62. The board looks at all surface ships conducting a maintenance availability in the next four years and determines if the ship requires a CSSQT. Recommendations from PEOs, PMs, TYCOMs and CSSQT Execution Agency, type of availability and the number of years since the ship conducted its last CSSQT allow the review board to make a decision if a ship should conduct a CSSQT. Once a ship is designated to conduct the trials, a test plan will be developed based on combat system requirements. The test plan is ship specific in which the scope is unique, but the objectives are the same.

The scope of a CSSQT is based on the warfare areas of the ship. The warfare areas that can be included in a CSSQT are:

- Air Defense Warfare (ADW)
- Strike Warfare (STW)
- Surface Warfare (SUW)
- Undersea Warfare (USW)
- Expeditionary Warfare (EXW)
- Electronic Warfare (EW)

CSSQT assess all combat/weapon systems that support each warfare area. A combat/weapon system is defined as a functional grouping of all the shipboard equipment, computer programs, personnel and documentation, plus other critical systems that are designed to detect, track, identify, communicate, process, evaluate, and execute the engagement of enemy forces, either actively passively (NAVSEA 2006). Not all ships are capable of all the above listed warfare areas so the scope of each CSSQT will depend on the capabilities of the ship. Regardless of the scope of the CSSQT, the objectives remain constant.

The objectives of CSSQT are “to verify and validate that the combat/weapon systems have been installed correctly and can be operated and maintained in a safe and effective manner” (NAVSEA 2006). Verification and validation is accomplished by subject matter experts (SMEs) assisting the crew with Planned Maintenance System (PMS) actions and also conducting in-port and at-sea combat system exercises. The exercises use live and/or simulated environments to stress the combat systems and ship's force in order to determine the level of maintenance readiness and operational readiness. Overall readiness is assessed using Measures of Effectiveness (MOEs) for adequacy of system documentation, logistics support, maintenance, and operational readiness. Assessing the MOEs and meeting the objectives of the CSSQT ensure the ship has a safe and effective combat system and is prepared for future training and operations.

CSSQT is a valuable experience for the ship's force because of the opportunity to work closely with subject matter experts (SMEs) while the crew learns to maintain the equipment and experiences how to operate it in real-world situations. The other benefit of CSSQT is the opportunity for engineers to conduct integrated Developmental and Operational Testing (DT/OT), to perform tactics validation and also conduct fleet training. The problem is a ship may only conduct one or two CSSQTs during the entire life of the ship, but combat and weapons systems are continuously being upgraded and/or added through the Navy Modernization Plan (NMP). It would be ideal for a ship to conduct a CSSQT after every major modernization, but due to the cost to conduct one it is not feasible. Based on the assessment of risk and significance it would be possible to recommend a CSSQT that is scoped down to ensure the major changes to the combat/weapon systems are validated and verified.

B. CURRENT WORK

NSWC PHD created the CSSQT Determination Process in 2012 to capture the process outlined in NAVSEAINST 9093.1C. It introduces two tools for determining the significance of changes being made to the ship and assessing the risk associated with the changes. Figure 2 shows the beginning of the determination process. The full flow chart can be found in Appendix A.

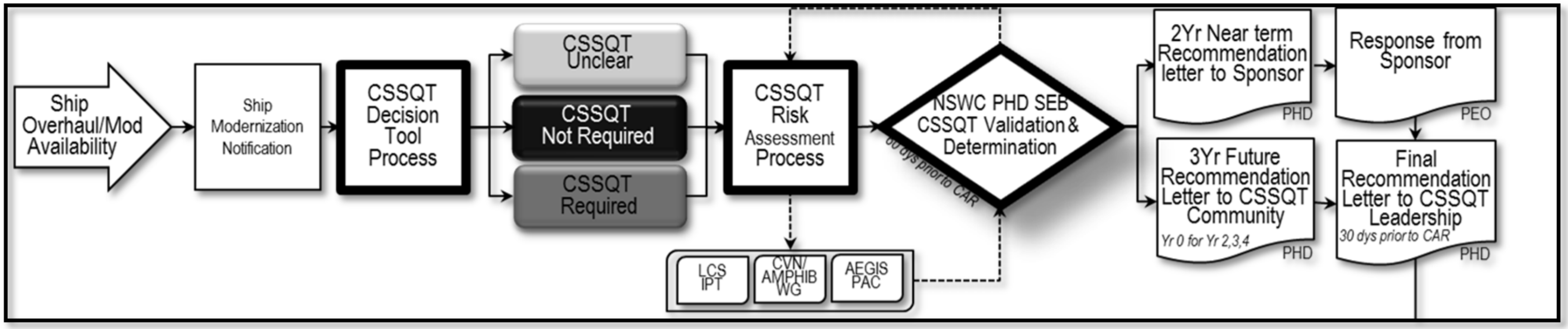

Figure 1. CSSQT Determination Process (From B. Hazle and S. Matthews, unpublished Powerpoint slide)

The process begins prior to the System Engineering Board (SEB) which occurs 60 days before the CSSQT Annual Review Board (ARB) (not pictured in Figure 2). The SEB reviews each ship that is scheduled to undergo an overhaul/modernization availability in the next four years. The SEB uses the assessments from the CSSQT Decision Tool process and the CSSQT Risk Assessment process to make a recommendation to the sponsors/CSSQT community that a ship should or should not conduct a CSSQT. Ships reviewed in previous years are reassessed for any changes to the ship's availability. The Decision Tool and Risk Assessment processes allow the SEB to make a more informed decision about designating ships for CSSQT. Each process will be discussed in more detail in the following sections.

1. CSSQT Decision Tool Process

The purpose of the CSSQT Decision Tool process is to determine the significance of the overhaul/modernization availability. The decision tool is a simple spreadsheet which lists the combat/weapon systems onboard the ship and assigns weights to each system based on the criticality to each warfare area and the type of modernization. Weights used for criticality and type of modernization were determined by the developers of the process. A detailed analysis of how the weights affect the results will be discussed in Chapter III. The criticality weight is multiplied by the modernization weight to yield a warfare area qualification weight. The sum of the warfare area qualification weights divided by the sum of the warfare criticality weights produces a percentage that represents the significance of changes being made to each warfare area. The average of the significance values represents the overall significance of the availability. The spreadsheet is populated using Warfare Interface System Engineering (WISE) database and Ship Change Documents (SCDs).

NSWC PHD uses the WISE database to determine when ships will be entering into a modernization period and to determine which systems will be changed. The database contains the current combat and weapon systems onboard the ship, which software version the systems are running and also when scheduled upgrades to the systems will occur. Each availability has a corresponding Warfare System Interface

Diagram (WSID) that is assessable from the WISE database. The WSID is a graphic that shows all combat and weapon systems, how they are connected to the command and control system and which systems are being modified during the availability. It also contains a list of the applicable SCDs and a description of the changes. An example of a WSID can be found in Appendix B. The WSID is used to populate the decision tool spreadsheet with the systems and get the applicable SCD numbers, but the SCDs are located in another database.

A SCD is the authorized document for any ship change during maintenance availabilities. All SCDs are located on the Navy Data Environment Navy Modernization Entitled Process database. SCDs contain a lot of information but the information used by NSWC PHD is about the type of modification being made to the system. It indicates if the system is being added to the ship, a new system is replacing an old system, the modification is adding a new capability, improving capability, improving performance, or improving infrastructure. This information is used in the decision tool to determine the modernization weight values. The weights used for each type of modification are shown in Figure 3. If a system is not being changed it receives a value of FALSE because there is not a category for a system not being altered.

Type	Weight
Replace with New	1
Add Capability	1
Improve Capability	1
Improve Performance	0.5
Improve Infrastructures	0.25

Figure 2. Modification Weights (From B. Hazel and S. Matthews, unpublished Excel spreadsheet)

The SCD does not show how vital a system is to a specific warfare area. The assessment of criticality is based on knowledge of how each system functions to support a specific warfare area. For example, a three-dimensional air search radar may be critical to anti-air warfare but unnecessary for the mission of surface warfare because surface warfare requires a surface search radar. NSWC PHD uses the categories and weights shown in Figure 4 to apply criticality to each system.

Category	Comments	Weight
Critical	Without this system cannot perform the mission (Mission Failure)	1
Necessary	Without this system mission can be performed but at a reduced success rate (Reduced Performance)	0.5
Like to have	Without this system mission can be performed but with reduced awareness (Reduces Situational Awareness)	0.25
Unnecessary for Mission	System does not affect mission (No Effect)	0

Figure 3. Mission Area Criticality Categories and Weights (From B. Hazel and S. Matthews, unpublished Excel spreadsheet)

The decision tool allows users to select the criticality category and modernization type from a drop down list. When a selection is made the weight value is automatically filled in and the spreadsheet will update the significance percentage. If the value is greater than 25% then a CSSQT is recommended and indicated on the spreadsheet. A completed decision tool is in Appendix C. After the CSSQT Decision Tool process the next step is to conduct a risk assessment.

2. Risk Assessment Tool Process

The risk assessment tool process has not been put into practice like the Decision Tool. It is still under development but NSWC PHD has developed a potential tool that could be used to assess the risk of a ship undergoing a major modernization. The tool assesses the risk to effectiveness, personnel, safety and readiness through a combination of subjective evaluations of the availability by Subject Matter Experts (SMEs), historical data about the ship, and current data about the availability. The developers of the tool, Bob Hazel and Sandra Matthew, from NSWC PHD defined the four areas of risk in the following way:

a. Effectiveness

The combat system is not able to perform its mission. Effectiveness risk is determined by the magnitude of changes impacting the combat/weapon system functionality (B. Hazel and S. Matthews, unpublished Excel spreadsheet).

b. Personnel

The combat systems cannot be operated effectively by the crew. Personnel risk is determined by the magnitude of changes impacting the crew's ability to operate and maintain systems (B. Hazel and S. Matthews, unpublished Excel spreadsheet).

c. Safety

Personal injury or death and/or equipment damage. Safety risk is assessed by the issues associated with a ship's modification, in conjunction with historical data, to determine the impact with individual or aggregate consequences (B. Hazel and S. Matthews, unpublished Excel spreadsheet).

d. Readiness

The combat system is not available/ready to perform the mission. Readiness risk is determined by the magnitude of changes impacting the combat/weapons systems ability to perform its mission (B. Hazel and S. Matthews, unpublished Excel spreadsheet).

There are 18 risk factors assigned to one or more of the categories that are used to assess the risk and Figure 5 shows how each risk factor is assigned to each risk category (an X indicates that risk factor is used in assessing the risk category).

Effective	Personnel	Safe	Material Readiness	RISK FACTORS
x			x	Years since last CSSQT
x			x	Years since last live firing
x	x	x	x	Complexity Change of Combat System
	x		x	Number of Changes in ILS Support (Tech Doc)
	x		x	Number of Changes in ILS Support (Test Equip)
	x		x	Number of Changes in ILS Support (Spares)
	x		x	Number of Changes in ILS Support (PMS)
x	x		x	Training Program Planned or Developed/Delivered (AIT)
x	x		x	Training Program Planned or Developed/Delivered (LBTS)
x	x		x	Planned ATG training
x	x	x		Certifications/Qualifications Impacted
x	x			Number of open R1 Trouble Reports (TRs)
x	x			Ship's force ability to perform the mission
	x		x	Known System Incidents of risks
		x		Known Safety Incidents of risks
	x			Manpower Requirements adequately reflected
x	x	x		Project Officer/Project Engineer Evaluation of Risk
x	x	x		Baseline Manager/Equivalent (i.e. Test Con./Dir. Evaluation of Risk

Figure 4. Risk Factor Assignments (From B. Hazel and S. Matthews, unpublished Excel spreadsheet)

The risk factors and how they are assessed is shown in Figure 6.

RISK FACTORS	Assessment
Years since last CSSQT	Enter number of years since last CSSQT
Years since last live firing	Enter number of years since last firing (reduces)
Complexity Change of Combat System	Modernization Impact percentage taken from the Decision tool
Number of Changes in ILS Support (Tech Doc)	PUBSAT: Calculate using SCD's. Count number of SCDs identified as impacting TECH DOC (Counting multiple SCDs to a single system only once)(X)/Total number of ships systems (XX) Tech docs checked/total number of systems
Number of Changes in ILS Support (Test Equip)	TESAT: Calculate using SCD's. Count number of SCDs identified as impacting TEST EQUIP (Counting multiple SCDs to a single system only once)(X)/Total number of ships systems (XX) ech docs checked/total number of systems
Number of Changes in ILS Support (Spares)	LOGSAT: Calculate using SCD's. Count number of SCDs identified as impacting SPARES (Counting multiple SCDs to a single system only once)(X)/Total number of ships systems (XX) ech docs checked/total number of systems
Number of Changes in ILS Support (PMS)	PUBSAT: Calculate using SCD's. Count number of SCDs identified as impacting PMS (Counting multiple SCDs to a single system only once)(X)/Total number of ships systems (XX) ech docs checked/total number of systems
Training Program Planned or Developed/Delivered (AIT)	Modernization Rep/SME
Training Program Planned or Developed/Delivered (LBTS)	B/L Mgr/SME
Planned ATG training	Training SME
Certifications/Qualifications Impacted	SCD Section 15/23
Number of open R1 Trouble Reports (TRs)	NWSCP R1 definition
Ship's force ability to perform the mission	NWSCP-Aggregate Assessment of number of Tactics, Techniques, and Procedures (TTP), workarounds, limitations, and restrictions indicates ship's force can perform the mission PRI 3/4's)
Known System Incidents of risks	Modernization Division System Engineer's evaluate known system incidents of risks
Known Safety Incidents of risks	SME evaluate known safety incidents of risks
Manpower Requirements adequately reflected	Fit/Fill
Project Officer/Project Engineer Evaluation of Risk	Evaluation of Ship Risk introduced from the specific changes occurring/occurred to a specific ship at a specific Ship yard with a specific Training Team
Baseline Manager/Equivalent (i.e. Test Con./Dir. Evaluation of Risk	Evaluation of Baseline Risks introduced from the specific changes occurring/occurred to a specific ship

Figure 5. Risk Factors and How they are Assessed (From B. Hazel and S. Matthews, unpublished Excel spreadsheet)

To complete the risk assessment each risk factor is assigned a weight based on the assessments that were conducted. Figures 7 through 10 show criteria and weights for each risk factor.

Risk Factors	High 1.0	Medium .5	Low .25	Not Effected 0
Years since last CSSQT	13-More years	12-8 years	7-3 years	2-Less years
Years since last live firing	10-More years (-0)	9-6 years (-25%)	5-3 years (-50%)	1-Less years (*-75%)
Complexity Change of Combat	50%-More	49%-25%	24%-1%	
Training Program Planned or	Not Planned		Planned	
Training Program Planned or	Not Planned		Planned	
Planned ATG training	Not Planned		Planned	
Certifications/Qualifications	15-More	14-7	6-1	0
Number of open R1 Trouble	2-More	1	0	
Ship's force ability to perform the	15-More	14-6	5-1	0
Project Officer/Project Engineer	High	Medium	Low	None
Baseline Manager/Equivalent (i.e. Test Con./Dir. Evaluation of Risk	High	Medium	Low	None

Figure 6. Effectiveness Criteria and Weights (From B. Hazel and S. Matthews, unpublished Excel spreadsheet)

Risk Factors	High 1.0	Medium .5	Low .25	Not Effected 0
Complexity Change of Combat	50%-More	49%-25%	24%-1%	
Number of Changes in ILS Support	50%-More	49%-25%	24%-1%	0%
Number of Changes in ILS Support	50%-More	49%-25%	24%-1%	0%
Number of Changes in ILS Support	50%-More	49%-25%	24%-1%	0%
Number of Changes in ILS Support	50%-More	49%-25%	24%-1%	0%
Training Program Planned or	Not Planned		Planned	
Training Program Planned or	Not Planned		Planned	
Planned ATG training	Not Planned		Planned	
Certifications/Qualifications	4-More	3-2	1	0
Number of open R1 Trouble	2-More	1	0	
Ship's force ability to perform the	15-More	14-6	5-1	0
Known System Incidents of risks	High	Medium	Low	None
Manpower Requirements	No		Yes	
Project Officer/Project Engineer	High	Medium	Low	None
Baseline Manager/Equivalent (i.e. Test Con./Dir. Evaluation of Risk	High	Medium	Low	None

Figure 7. Personnel Criteria and Weights (From B. Hazel and S. Matthews, unpublished Excel spreadsheet)

Risk Factors	High 1.0	Medium .5	Low .25	Not Effected 0
Complexity Change of Combat	50%-More	49%-25%	24%-1%	0%
Certifications/Qualifications	4-More	3-2	1	0
Known Safety Incidents of risks	High	Medium	Low	None
Project Officer/Project Engineer	High	Medium	Low	None
Baseline Manager/Equivalent (i.e. Test Con./Dir. Evaluation of Risk	High	Medium	Low	None

Figure 8. Safety Criteria and Weights (From B. Hazel and S. Matthews, unpublished Excel spreadsheet)

Risk Factors	High 1.0	Medium .5	Low .25	Not Effected 0
Years since last CSSQT	13-More years	12-8 years	7-3 years	2-Less years
Years since last live firing	10-More years (-0)	9-6 years (-25%)	5-3 years (-50%)	1-Less years (*-75%)
Complexity Change of Combat	50%-More	49%-25%	24%-1%	
Number of Changes in ILS Support	50%-More	49%-25%	24%-1%	0%
Number of Changes in ILS Support	50%-More	49%-25%	24%-1%	0%
Number of Changes in ILS Support	50%-More	49%-25%	24%-1%	0%
Number of Changes in ILS Support	50%-More	49%-25%	24%-1%	0%
Training Program Planned or	Not Planned		Planned	
Training Program Planned or	Not Planned		Planned	
Planned ATG training	Not Planned		Planned	
Known System Incidents of risks	High	Medium	Low	None

Figure 9. Readiness Criteria and Weights (From B. Hazel and S. Matthews, unpublished Excel spreadsheet)

After the assessment is completed the results are entered into a spreadsheet that calculates the risk score for each risk category and the overall risk score for the ship. An example of a completed risk assessment is shown in Figure 11.

ENTER SHIP NAME AND FY OF CSSQT	Risk Assessment				
Risk Factors	**ENTER DATA**	**Effective**	**Personnel**	**Safe**	**Material Readiness**
Years since last CSSQT	2	0			0
Years since last live firing	0	0.0			0.0
Complexity Change of Combat System	37%	.5	.5	.5	.5
Number of Changes in ILS Support (Tech Doc)	19%		.25		.25
Number of Changes in ILS Support (Test Equip)	52%		1.0		1.0
Number of Changes in ILS Support (Spares)	4%		.25		.25
Number of Changes in ILS Support (PMS)	4%		.25		.25
Training Program Planned or Developed/Delivered (AIT)	Not Planned	1.0	1.0		1.0
Training Program Planned or Developed/Delivered (LBTS)	Planned	.25	.25		.25
Planned ATG training	Planned	.25	.25		.25
Certifications/Qualifications Impacted	13	.5	.5	.5	
Number of open R1 Trouble Reports (TRs)	5	1.0	1.0		
Ship's force ability to perform the mission	15	1.0	1.0		
Known System Incidents of risks	Medium		.5		.5
Known Safety Incidents of risks	Medium			.5	
Manpower Requirements adequately reflected	Yes		.25		
Project Officer/Project Engineer Evaluation of Risk	Low	.25	.25	.25	
Baseline Manager/Equivalent (i.e. Test Con./Dir. Evaluation of Risk	Low	.25	.25	.25	
TOTAL	**44.64%**	**45.45%**	**50.00%**	**40.00%**	**38.64%**

Figure 10. Completed Risk Assessment Example (From B. Hazel and S. Matthews, unpublished Excel spreadsheet)

The risk score for each category is the sum of risk factor weights divided by the total number of risk factors for the specific category. The total score for the overall risk assessment is the sum of all risk factor weights divided by the total number of risk factors. Each risk category is given a severity rating based on the category score:

- >51% Red Severity Rating
- >26% and <51% Yellow Severity Rating
- >1% and <26% Green Severity Rating
- 0% and <1% Blue Severity Rating

The higher the score the greater risk the ship may experience post-availability to effectiveness, personnel, safety and readiness. The risk assessment gives the CSSQT Certification Authority and other decision-makers the ability to make a stronger recommendation for a ship to be designated to conduct a CSSQT. A low risk assessment score indicates the changes being made to the ship will not have an impact on the readiness of the ship and therefore a CSSQT may not be required even if the CSSQT decision tool recommends a CSSQT.

The next chapter will investigate the current work to find if there is a better approach to the two tools. The tools are undeveloped and lack validation due to the short time they have been use. The goal is to develop a tool that captures both the significance and risk in one tool/process rather than having two separate tools that are not coupled.

III. METHODOLOGY

The approach used for this research consists of three stages. The first stage develops a methodology for reviewing the CSSQT Decision Tool process and determines if it is achieving the desired results of the process. The second stage creates a methodology for assessing risk and reviews the Risk Assessment process and. The third stage develops an approach to present significance and risk in a manner that gives decision-makers a better understanding of how the modernizations are impacting the ships in a given fiscal year. This chapter will only present the methodologies for each stage. The results of the methodologies will be presented in Chapter IV.

A. CSSQT DECISION TOOL REVIEW

The goal of this stage is to create a methodology to review the current CSSQT Decision Tool process being used by NSWC PHD. The methodology needs to determine what the process is trying to accomplish and what is needed to do this. Another way to say this would be what is the function of the process and what functions are required to achieve the overall function. When looked at in this way the best approach is to use a functional decomposition.

A functional decomposition will show what functions the tool will need to do to achieve the overall purpose. The first step is to define the overall function of the process. The second step is to create a functional decomposition and the third step is to examine the current tool to see if it performs the functions. The Decision Tool review will use a completed assessment of 10 ships conducting modernization availabilities in fiscal year 2015.

The purpose of the CSSQT Decision Tool process is to determine if the modifications being made to the ship during a maintenance availability are significant. The need for this determination is because NAVSEAINST 9093.1C states that ships will conduct a CSSQT if the overhaul/modernization is significant. Defining significant is essential to the assessment. Significant, for the purpose of this process, is defined as *any change or combination of changes that reduce the overall combat readiness of a ship.*

Using the definition, a maintenance availability is not significant if the changes being made to the combat/weapon systems do not reduce the ship's ability to execute its assigned missions. However, there can be degrees of how significant the changes are beyond not significant. If the impact on the combat readiness is minimal then it can be determined that the overhaul is somewhat significant. When the changes greatly reduce the combat readiness than the overhaul is extremely significant. To determine just how significant the changes are, a scale needs to be implemented to quantify the changes being made to the ship.

For the CSSQT Decision Tool to accurately determine how significant the overhaul is, it must first define a quantifiable scale for significance. Significance is the quantitative value for how significant the modifications the overhaul is; therefore, a finite interval scale can be used to assign a value to how significant the changes are. A scale that spans from 0 to 10, where 0 is not significant and 10 is extremely significant will allow the process to assign values for significance. The overall function of the CSSQT Decision Tool is to quantify the impact to each system in terms of significance so the aggregate of all the systems yields a value that can be used on an interval scale to determine if the overhaul is significant.

The approach for determining the significance of changes requires quantifying the impact the changes have on the combat system. The functions of the process need to provide a quantitative analysis of the changes being made to the different systems based on their importance to the warfare areas and the type of modification being made to the systems. The result of this analysis will yield the level of change being made to the combat/weapon system and the level can be used on an interval scale to show if the change is significant. The process will have top-level functions and sub-functions that are required to ensure the overall function is possible. These functions are shown in the functional decomposition in Figure 12. The following sections describe each function and reviews of the CSSQT Decision Tool's ability to perform the functions.

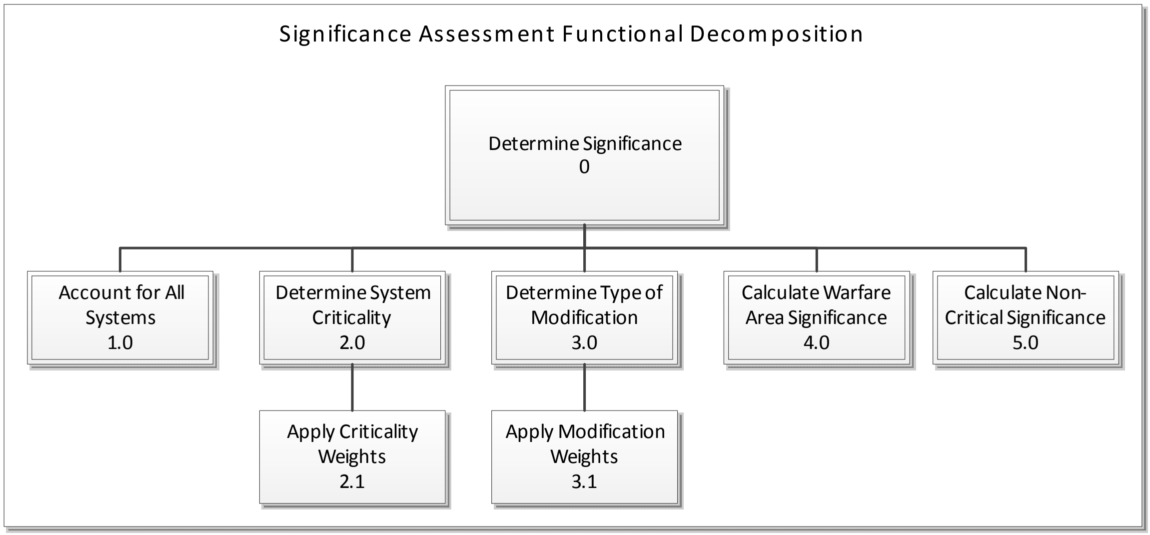

Figure 11. Significance Functional Decomposition

1. Account for All Systems

The first step in determining significance is to accurately account for all combat/weapon systems installed on the ship. Ensuring all systems are included in the assessment will reduce the risk of omitting a major change that could potentially impact the ship's readiness. The current process does list the systems but the review found the list was inaccurate and also grouped systems based on common functions. The list of systems in the reviewed completed assessment contained systems that were not installed and also did not list installed systems. Training systems were grouped into one system which resulted in a lack of understanding which system is being modified, in the case there is a modification. In most cases, at least one of the three training systems onboard a ship were being modified in some way; but, it was unclear which system was being affected. Training systems are considered non-critical to the mission of the ship; however, they are vital to ensuring the crew is trained to execute the mission. They must be treated in the same manner as other major systems and each system evaluated individually versus grouped.

The class of ship may be the same but the systems onboard the ship can differ immensely. It is vital to the process that each system is accounted for so changes are assessed properly. The WISE database has the capability to allow users to download a list of systems, in spreadsheet format, onboard a ship post-availability. This capability must be used for each ship being assessed to ensure all systems are accounted for. The next function is to determine how critical each system is to each warfare area.

2. Determine System Criticality

System criticality is dependent on how the system integrates into the detect-to-engage path for each warfare area. The assessment is done by determining if the warfare area mission can still be accomplished without that specific system. The criticality will determine the weight that will be assigned to the system. The current process does apply mission area criticality to each system and the categories were discussed in Chapter II. The review found that the first three categories are appropriate for assessing the criticality but the *Unnecessary for Mission* category needs to be addressed. All systems onboard ships have some necessity in completing the mission. For this reason, the category needs to be changed to *Non-Critical*. This change makes it clear that a system may not directly be required for a mission area but is still important to the overall mission readiness of the ship.

a. Apply Criticality Weights

The purpose of a criticality weight is to quantify the criticality. A system is assigned a category based on how critical it is to the warfare area, but the category needs to be converted to a number for use in the formula for determining impact on the warfare area. The scale used for criticality is a non-dichotomous ordinal scale because it spans a spectrum of how critical a system is to a warfare area. Typically, a scale of this nature will have numbers associated with each category. For example, a survey of opinion might have the categories of *completely agree, mostly agree, no opinion, mostly disagree, and completely disagree* where the values for the categories would be 5, 4, 3, 2 and 1, respectfully. The equal separation between values demonstrates a consistent decline if the magnitude of the categories. If the separation is not consistent in this type of scale than the concern is the full spectrum is not captured by the categories.

Capturing the full spectrum is important for determining the criticality weights. If a system is not critical, the next category should be indicative of the next level of criticality. The value should also represent one step down from the previous value. The range between the values can be considered the magnitude of difference between categories. When the separation between category values is equal, there is an equal magnitude of difference between categories indicating a consistent decrease from one category to the next. If the magnitude of difference is not equal, it could indicate another category is required to ensure the scale includes all required categories. The criticality categories, *Critical, Necessary, Like to Have, and Non-Critical* can be plotted on a number line, with equal intervals, that ranges from 0 to 1, and a system categorized as *Critical* would earn a value of 1 and a *Non-Critical* system would earn a value of 0. A *Like to Have* system would have a value of 0.33 and a *Necessary* system would have a value of 0.66. The equal separation ensures the categories represent the entire range of criticality.

NSWC PHD gives a *Critical* system a weight of 1, a *Necessary* system a weight of 0.50 and a *Like to Have* system a weight of 0.25 indicating a *Critical* system is two magnitudes more critical as a *Necessary* system, but a *Necessary* systems is only a single magnitude more critical than a *Like to Have* system. The problem with this approach is there is no justification for why the separation between categories is different. It should be understood why a *Critical* system is more critical than a *Necessary* system, but NSWC PHD does not address the reason in the description of the tool. It is possible that the selection of weights does not affect the results of the analysis and therefore a justification of why the values used for the weights is not necessary.

A sensitivity analysis on the values for the weights was conducted to determine if changing the values will result in a different outcome of the assessment. There are two possible outcomes of the assessment: *CSSQT Required* or *No CSSQT Required*. Out of the ten ships assessed, six resulted in *No CSSQT Required* with the weighting scheme used by NSWC PHD. The first analysis changed the weights so there was a single magnitude of difference between the categories and there was no change to the outcome of the assessment. The second analysis changed the value of the weight for

Necessary, Like to Have and *Non-Critical* systems to 0.75, 0.50, and 0.25, respectfully, and the results were not affected. Each analysis maintained the weight for a *Critical* system as 1 and the values for the other weights were separated by an equal magnitude. The analysis was performed to show if the values for the weight influence the outcome of the assessment, in both cases the outcome was not affected.

The values for the criticality weights do not influence the results of the assessment and the methodology presented recommends changing the values. Changing the weight values corrects a problem with how the overall significance is calculated. The current process multiplies the criticality weight by the modification weight to determine the significance a change has on an individual system. When a non-critical system is being modified, it does not factor into the significance because a *Non-Critical* system has a weight of 0. To maintain an equal separation of weights, a *Non-Critical* system will have a weight of 0.25, a *Like to Have* system a weight of 0.50, and a *Necessary* system a weight of 0.75. The process for including systems that are considered *Non-Critical* will be discussed in the section describing the function of calculating noon-critical significance.

3. Determine Type of Modification

The type of modification evaluates if a systems is being altered during the availability and the nature of the alteration. There are five categories of modifications, the categories and the descriptions are shown in Figure 13.

Type	Comments	Example
Replace with New	This is a significant change to the combat system. Disrupts the DTE data path	Replace ACDS with SSDS, SYS-2 with CEC
Add Capability	This is a significant change/addition to a mission area	Add CIWS to a platform, NSSMS surface mode
Improve Capability	This is a significant change to a systems capability	ESSM, IFF mode V
Improve Performance	This is a significant change to a systems performance	NSSMS solid state transmitter, 48G
Improve Infrastructures	This is a significant change to a systems configuration	SSDS open architecture

Figure 12. Modification Types and Descriptions (From B. Hazel and S. Matthews, unpublished Excel spreadsheet)

The main issue with the type of modification categories is there is not a category for a system not being changed. This leads to the decision tool having blank cells that gives no information to the user. A blank cell could indicate that the system has not been evaluated or the type of change is unknown. A sixth category needs to be added to account for systems not being changed during the availability.

a. Apply Modification Weights

The purpose of applying weights to the modification type is to quantify the impact the modification has on the system. As discussed previously, the modification weight and the criticality weight are used to score the significance of the changes to a warfare area. The weighting scheme used by NSWC PHD give equal value to the first three types of modifications indicating the impact to the system is the same for each modification. The last two categories have a lesser amount of weight indicating the modification does not impact the system as much as the other modifications. The same scale used for the criticality weights is used for the modification weights. The first three modification types are assigned a weight of 1, the fourth type has a value of 0.50 and the last category is given a weight of 0.25. Again, there is an unequal separation between the types of modifications. The weighting scheme indicates a modification that replaces an old system or adds or improves the capability of a system will impact the system twice as much as a modification that improves the performance of the system and an improvement to performance has twice the impact as an improvement to infrastructure. Since the weights are assigned based on the potential impact the modification has on a system, it is possible the outcome of the assessment can be impacted by changing the values of the weights.

Sensitivity analysis was performed to determine if the values of the weights are critical to the outcome of the assessment. Two analyses were conducted to determine if the recommendations of the Decision Tool can be changed if the values for the weights are altered. The first analysis increased the values of the *Improve Performance* and *Improve Infrastructure* to 0.90 and 0.50, respectfully. The second analysis decreased the weights to 0.30 and 0.10. The weights of the first three types of modifications were not changed because it is understood the impact to the system is the greatest when one of these modifications occur. The outcome of the assessments of ten ships did not change in either of the two analyses. Further analysis would be required if the outcomes did change to determine the sensitivity of the model. This simple sensitivity analysis demonstrates the model is not sensitive to changing the weights and therefore, the weights will not be changed.

4. Calculate Warfare Area Significance

The purpose of this function is to determine the magnitude of impact the changes to the systems has on a warfare area. This is computed by multiplying the criticality weight by the modernization weight. If a system is not affected during the availability, the score will be zero because the weight of no change is zero. The highest score an individual system can receive is one. The sum of all the individual system scores will yield the impact to the warfare area. This value will range from 0 to 10 (in most cases, there is the possibility that the value could be greater than 10, but it is not likely) where 10 indicates a significant amount of modification is being made to the combat/weapon systems. The review found the current process does this calculation, but does another calculation that is not necessary.

NSWC PHD determines the significance of changes made to each warfare area by taking the sum of individual impact scores and dividing it by the sum of the criticality weights. The ratio of warfare area impact to warfare area criticality yields a value that is converted to a percentage. The percentage is what is used to indicate the amount of change. The flaws with this method are, 1) it does not capture non-critical systems that are being altered during the availability, 2) a ratio is intended to compare two similar values and in this model the two values are not similar and 3) the result is in a form of a percentage but it is unclear what it is a percentage represents. The solution to the first flaw is to calculate the significance to non-critical systems which will be discussed in the next section. The last flaws can be resolved by not doing the calculation and only using the sum of the warfare area significance scores.

5. Calculate Non-Critical System Significance

The purpose of this function is to account for systems that are not critical to a major warfare area. All combat/weapon systems are important to the overall mission of the ship but some will not directly support primary warfare areas. Changes to these systems must be accounted for to determine if the modernization availability will have significant changes. The reason for accounting for non-critical systems is because any change will impact the crew's ability to operate the equipment. For example, a hardware change to the air traffic control system may not impact air defense or surface warfare, but it does impact the ship's ability to recover aircraft. These non-critical systems must be included in the overall assessment of significance. The non-critical system significance is calculated in the same way the warfare area significance is calculated; how it is implemented will be discussed in Chapter IV.

B. STAGE 2

The risk assessment tool process addresses risk to a ship's readiness after an overhaul/modernization availability. The current process used by NSWC PHD is still under development and has not been implemented to assess the risk for any ship conducting a modernization availability. For this reason, the best approach is to determine a way to assess the risk associated with a major overhaul. After a practical method is developed to determine the risk, the next step is to review the proposed process discussed in Chapter II.

1. Risk Assessment Methodology

The difficulty with risk assessment is trying to predict the future based on current knowledge. The first step for assessing risks requires understanding all the possible outcomes, determining what can cause those outcomes, and the probability of each cause occurring. The next step is to apply a severity to each outcome; the greater the severity, the greater the risk. Risk is defined as a measure of the probability and severity of adverse effects (Haimes 2009, 4). There are many methods that can be used to assess risk, but all methods essentially start with the following three questions:

- What can go wrong?

- What is the likelihood that it would go wrong?
- What are the consequences? (Haimes 2009, 24)

The methodology for this research will begin with these three questions. To begin the assessment it is important to understand the goal of CSSQT. Figure 14 shows that the goal of CSSQT is to ensure a safe and effective combat system.

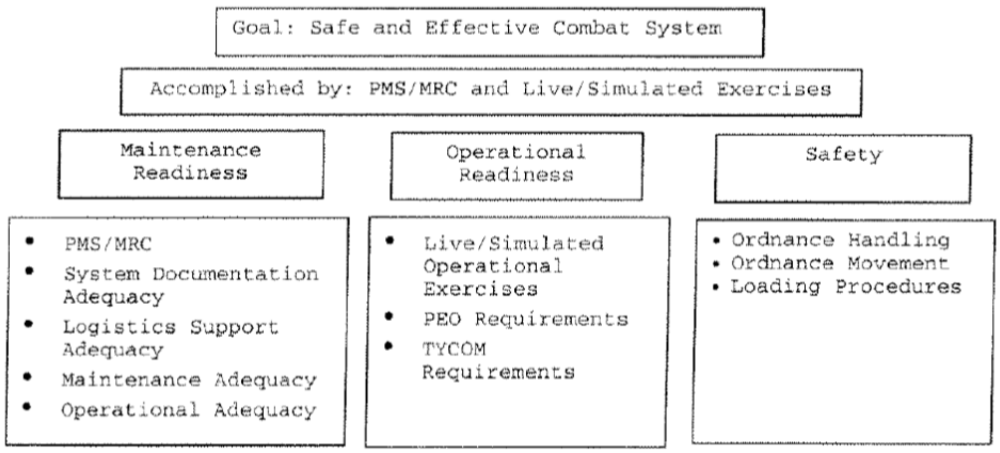

Figure 13. CSSQT Goals, Objectives, and Requirements (From NAVSEA 2006)

The three areas that ensure a safe and effective combat system are maintenance readiness, operational readiness and safety. Figure 13 provides categories for answers to the first question of “What can go wrong?” They include: the ship may not be able to accomplish maintenance actions, the ship may not be operationally ready, and the crew may not be able to safely handle ammunition. The third question focuses on the consequences from the answers to what can go wrong. If a ship is not operationally ready, then the training cycle may take longer or require more man hours and could lead to schedule changes or delayed deployments. If the crew is unable to maintain the new equipment, then the consequences could be increased technical assistance, and longer equipment downtime. This risk assessment will not focus on the consequences but only, address the likelihood of what can go wrong.

Answering the second question about the likelihood of a risk occurring is what this risk assessment is going to accomplish. CSSQT ensures the ship has a safe and effective combat system after significant overhaul/modernization, but what is the likelihood of a ship not being safe and effective if a CSSQT is not conducted? The significance assessment may result in an overhaul/modernization being classified as *significant* but, the assessment is based on the type of changes and how the changes impact the warfare areas. The risk assessment addresses how the entire availability, not only the modifications, affect the three areas reviewed by CSSQT. If the maintenance availability does not impact the maintenance readiness, operational readiness, or safety of the ship, than it may not be necessary to conduct a CSSQT even if the availability is deemed *significant.* Cause-Effect diagraming will be used to determine how the availability, as a whole, impact the three focuses of CSSQT.

During the availability, what is being added or changed, how long is the availability, what is the time lapse since training cycle, or whether there is crew turnover can have great impact on how well the ship's force can maintain and operate its new combat system. A cause and effect diagram can be used to show which areas are at risk. Figure 15 depicts how a safe and effective combat system is achieved by conducting a CSSQT.

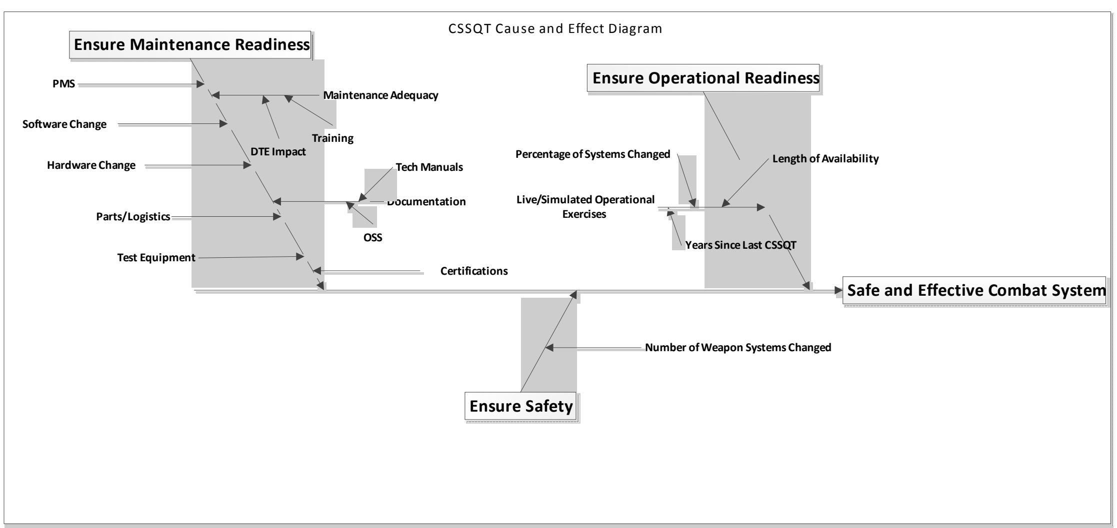

Figure 14. Cause-Effect Diagram

Cause and Effect diagrams are usually used to find the root cause of a problem, but in this case the goal is to find what influences a positive outcome. The diagram can also be used to determine the risks to the causes. Each cause can be broken down into secondary causes and these causes can be used to determine what drives each primary cause. For example, CSSQT ensures operational readiness by performing live and/or simulated operational exercises. If operational exercises are not performed by the crew then operational readiness cannot be ensured; therefore, the ship has a risk of not having a safe and effective combat system. The secondary cause can be broken down further (if required) to address potential risk factors that can be used to assess the risk to each primary cause. Each arrow on the diagram represents a risk factor. Each risk factor needs to be investigated to determine a way to quantify the risk.

The three area of focus are maintenance readiness, operational readiness, and safety; these are the risk areas for overall ship readiness. Measuring the risk to the ship's readiness will be a function of the risk to the three risk areas. The goal is to quantify the risk in a way the represents the likelihood of risk; that is, the higher the value the more likely the ship will not be operationally ready. The next sections will break down each risk area and discuss measuring the risk.

a. Risk to Maintenance Readiness

Maintenance readiness is the ship's ability to maintain the combat/weapon systems onboard. Prior to entering a major availability, the crew has the right people trained to maintain the equipment and will have accumulated months of experience maintaining it. After the availability, the maintenance readiness may be decreased because a system that has been upgraded, replaced or installed may affect the hardware, software, planned maintenance system, technical manuals, supply parts, certifications, Operating Sequencing System (OSS), detect-to-engage path, training, and test equipment. These are the risk factors taken from the cause and effect diagram. Not all of these factors will be affected, so the assessment of risk to maintenance readiness will determine what is being changed and quantify the changes.

The main source of data for impact to maintenance readiness is a SCD. As discussed previously, SCDs contain information about administrative functions and the impact on maintenance readiness. A SCD consists of 26 sections and the following sections are used to determine the risk to maintenance readiness:

- Section 4a and 4b: Scope and Category
- Section 11: Executive Summary
- Section 12: Description of Change
- Section 13: Impact if not Accomplished
- Section 14: Requirements and Justification of Change
- Section 15: Distributive Systems/Other Impacts
- Section 16: Human Systems Integration Impacts
- Section 17: Integrated Logistics Support (ILS) Impact
- Section 23: Certifications/Qualifications

The scope and category will indicate if it is a hardware change, software change or both. Sections 11, 12, 13, and 14 can all be used to understand the nature of the change, such as if a new system is replacing an old system. Section 15 describes how the alteration impacts other systems on the ship. Section 16 will indicate how training is impacted. Section 17 lists all ILS systems that are impacted and Section 23 lists the certifications that will be required after the installation. SCDs, in most cases, do not describe the impact a change will have on a specific maintenance area.

Due to the size of an SCD only one section is presented here to demonstrate how the information is presented. Figure 16 is an example of what is found in section 17 of a SCD. The only information that can be inferred from this section is the change will affect technical manuals and provisioning.

	Impact
☒	Technical Manuals
☒	Provisioning
☐	Planned Maintenance System
☐	Ship's Selected Records
☐	Operating Sequence Systems
☐	Steam Plant Manual
☐	Test Equipment
☐	COTS/NDI
☐	Facilities

Figure 15. SCD Section 17: Integrated Logistics Support (ILS) Impact

It is not known if technical manuals will be added, removed or updated or how the supply systems (provisioning) will be impacted. If this information was available it may be possible to use an assessment approach that uses the number of changes being made to each area. For example, if the system before the change required 45 spare parts onboard and after the change the system will require 60 spare parts than the 33% increase in the number of parts could be used to indicate a certain likelihood that maintenance readiness will be impacted. The reason maintenance readiness could be impacted is because of the possibility the supply system does not get updated with the correct parts. If the ship is not stocked with the correct parts than a delay in repair could occur causing longer downtime of the system. CSSQT verifies that the ship has the correct parts onboard for each system therefore reducing the likelihood of this situation occurring. The assessment, if this information was present, could set thresholds for the amount of change being made to an area and make a better determination of risk if the threshold is exceeded.

Information on how each area is being affected is not available therefore, a binary system is the best approach to evaluate the changes being made to the system; if a box is checked then the category receives a one, if not checked it receives a 0. This method can be used on each system being impacted by the availability. There are ten categories that relate to maintenance readiness, so if a specific system scores a 10 then all areas are being affected by the change. The average score of the all the systems will yield a value that is indicative of how much the availability is impacting the maintenance readiness. The higher the score, the more likely there will be a risk to maintenance readiness post-availability.

b. Risk to Operational Readiness

Operational readiness is the adequacy at which the ship's force can operate its combat system and the ability of the equipment to operate as designed. The secondary indicator of operational readiness is performance of live and/or simulated operational exercises. When a ship conducts a CSSQT it will perform multiple simulated warfare specific scenarios that stress the combat/weapon systems and the ship's crew. The final exercises will usually involve live firing of missiles and guns against unmanned drones and other targets. Most ships will only get to conduct live firing during CSSQT, but all ships conduct simulated exercises during the training cycle and during deployments. Determining the risk to operational readiness involves these two aspects of a ship's life: Time lapse since last CSSQT and length of availability. The latter is under the assumption that a majority of ships return from deployment and enter the maintenance phase. A third aspect that can be used to determine operational readiness risk is the percentage of systems modified during an availability. The more systems that are changed, in most cases, the less familiar the crew will be with operating them. The ability to use the systems as designed in a stressing situation decreases because of the novelty of the revised system. The likelihood of risk to operational readiness will be a function of time lapse, length of availability and percentage of systems changed. The likelihood will range from 0 to10 where 10 would indicate the greatest likelihood.

c. Risk to Safety

The area of safety CSSQT addresses is ordnance safety. Ordnance handling, movement, and loading is a high risk evolution and if a ship has not had training on the proper procedures for an extended period of time, the risk is increased. What can go wrong is the mishandling of ordnance or improper loading procedures which can lead to mishaps that can cause injury or even death. The likelihood of the ship not being safe is a function of the weapons systems being altered during the availability.

If an availability will affect all weapon systems onboard than the likelihood of risk is the greatest. In this case the ship will receive a score of 10. If no weapon systems are being upgraded or added then the risk is the lowest yielding a score of 0. When there is one or more weapon system is being modified, but not all, then the score will be a 5.

2. Review of Current Risk Assessment Process

The risk assessment methodology shows the functions required for the assessment are determining the risk areas, the risk factors for each area, and a way to quantify the risk factors. Another function, that was not discussed, is the ability to repeat the assessment in a way that will ensure consistent results. This means that the data used to conduct the assessment must lack any sort of subjective assessment. NSWC PHD has developed a process to assess risk and it was described in Chapter II. This process identified four risk areas and 18 risk factors. It also quantified the risk factors so they could be used to formulate a value for likelihood. The issue with the proposed process is that it relies on factors that are subjective.

There are five risk factors in the proposed process that solicit an evaluation of a SME. The five factors are:

- Ship’s force ability to perform the mission
- Known system of incidents of risks
- Known safety incidents of risks
- Project Officer/Project Engineer evaluation of risk
- Baseline Manager/Equivalent evaluation of risk

The evaluation by SMEs can differ greatly from ship to ship and it is important all subjective assessments are removed when conducting a quantitative assessment. It also introduced a level of complexity because the execution of the assessment relies on the input of outside entities. There are other risk factors that rely on the input from other agencies to complete the assessment and those are:

- Training program planned or developed/delivered(AIT)
- Training program planned or developed/delivered(LBTS)
- Planned ATG Training

- Manpower requirements adequately reflected

The problem with using the inputs from outside sources is potential delays in gathering information. In any given fiscal year there will a large number of ships conducting an availability and it is the advantage to the assessors to rely on one or two sources for data. The current process could take an assessor weeks to complete while the methodology described in the previous section is able to be completed in days.

The other issue with the risk assessment process proposed by NSWC PHD is that it does not follow the goals of the NAVSEAINST 9093.1C. The instruction specifically outlines what CSSQT accomplishes and the risk assessment should coincide with the objectives of the instruction. There are only three areas that CSSQT addresses but the proposed process describes four areas. Each area in the instruction had specific factors that are reviewed by the CSSQT but the proposed process has multiple factors that apply to more than one of the four areas. The risk assessment should be precise and lack any ambiguity; however, the proposed risk assessment process is full of ambiguity and does not provide a precise measure of the likelihood that the ship's readiness is at risk.

C. STAGE 3

The purpose of this stage is to develop a methodology for presenting the results from the significance assessment methodology and risk assessment methodology. The current process used by NSWC PHD uses a separate spreadsheet to assess the significance and another one for the risk assessment. The only interface between the two processes is that the result of the significance assessment is used in the risk assessment as a risk factor. NSWC PHD has proposed that the results of the assessment will be reported on a single page that is divided into four quadrants (commonly referred to as a quad-slide) where one quadrant gives information about the ship, another one for administrative data, and the last two show the results of the assessments. The issue with this approach is that there is no coupling of results of the assessments.

The end result of the two assessments should result in an understanding of the overall impact to the ship. Overall impact is a function of the how significant the changes are and the likelihood that the changes will affect the ship's readiness. The presented methodologies put significance and likelihood on the same sized scale so it makes it possible plot the two areas in a matrix. The reason for plotting the two areas is to give a visual representation of the results. When each ship is plotted on the same matrix, decision-makers will have the ability to determine which ship will be impacted the greatest and also know which ships can proceed without a CSSQT. The approach for presenting the results will be to use a summary spreadsheet that captures each ship conducting an availability in a given fiscal year, information about each ship's availability and history, the results of the significance assessment, the results of the likelihood assessment and a matrix that plots each ship.

This chapter developed methodologies for determining if the changes being made to a ship during a modernization are significant, if the changes being made impact the readiness of the ship, and a way to present the results. It also reviewed the current tools being used by NSWC PHD to determine shortfalls and issues. The review found that there are issues with the current tools that need to be addressed. The next chapter will use the methodologies to develop a tool that will determine significance and likelihood and present the results.

IV. RESULTS AND ANALYSIS

The previous chapter discussed issues with the current process for determining the impact to a ship's readiness after a major availability and also developed methodologies to implement a better process. The results of implementing the methodologies will be described in this chapter. The first step designs a spreadsheet that presents the information about each ship being assessed, the results of the significance assessment, and the results of the risk assessment. The second step is to conduct the significance assessment and risk to maintenance readiness assessment. The final step plots the significance and risk likelihood for each ship on a matrix. The end product will be a single spreadsheet that presents the results of the significance assessment, risk assessment and matrix.

The analysis will use data about ships that are scheduled to conduct a major availability in fiscal year 2015. The ships used for the assessment are:

- USS Nimitz (CVN 68)
- USS George HW Bush (CVN 77)
- USS Harry S Truman (CVN 75)
- USS Ronald Reagan (CVN 76)
- USS Germantown (LSD 42)
- USS Gunston Hall (LSD 44)
- USS Ashland (LSD 48)
- USS Carter Hall (LSD 50)
- USS Pearl Harbor (LSD 52)
- USS Makin Island (LHD 8)

All information needed to conduct the assessment is available in three locations: WISE Database, Navy Data Environment (NDE), and NSWC PHD ship information database. The WISE database contains information about the availability and the systems onboard the ship. SCDs are located in the NDE and the ship information database has the results of the previously conducted CSSQT.

A. CSSQT DETERMINATION DASHBOARD

The CSSQT Determination Dashboard is a central location that presents the information gathered during the assessment. The dashboard uses information about the availability, the results of the assessments and does calculations to determine the significance of changes and risk likelihood. Figure 17 shows what a completed dashboard looks like.

FY15																	
CSSQT Determination Dashboard																	
Availability Data				Significance Assessment				Risk Assessment									
Ship	Avail	Avail Start	Avail End	AD Impact Score	SUW Impact Score	Non-Crit Weight	Significance Score	Avail Length (Years)	Total Systems	Total Systems Changed	% Systems Changed	Last CSSQT	Delta (Years)	Operational Readiness Score	Maintenance Readiness Score	Safety Score	Risk Likelihood
CVN 68	PIA3	May-14	Feb-15	5.13	4.13	0.31	4.94	0.75	29	13	45%	2007	8	2.77	6.77	10	6.51
CVN 77	PIA1	Apr-15	Oct-15	5.63	3.88	0.69	5.44	0.50	31	13	42%	2009	6	1.94	7.08	10	6.34
LSD 42	SRA	Jan-15	Apr-15	1.00	1.00	0.00	1.00	0.25	18	2	11%	1986	29	1.11	5.5	1	2.54
LSD 44	PMA3-2	Sep-14	Jan-15	5.00	4.75	0.69	5.56	0.33	20	14	70%	1989	26	7.00	6.57	10	7.86
LSD 48	SRA	Aug-14	Nov-14	2.50	3.13	0.00	2.81	0.25	19	7	37%	1992	22	3.68	5.71	1	3.47
LSD 50	EDPMA	Jan-14	Jan-15	6.25	6.00	0.75	6.88	1.00	20	15	75%	1995	20	7.50	6.80	10	8.10
LSD 52	EDPMA	Feb-14	Feb-15	6.25	5.13	0.63	6.31	1.00	20	14	70%	1998	17	7.00	6.80	10	7.93
CVN 75	PIA2	Sep-14	Mar-15	5.50	3.00	1.25	5.50	0.50	31	16	52%	2007	8	3.16	7.00	10	6.72
CVN 76	PIA2	Oct-14	Apr-15	5.00	4.00	2.00	6.50	0.50	32	16	50%	2008	7	2.69	6.75	10	6.48
LHD 8	PMA1-2	Feb-15	Aug-15	3.75	3.50	0.13	3.75	0.50	29	8	28%	2009	6	1.28	7.5	10	6.26

Figure 16. Completed CSSQT Determination Assessment

Figure 16 is used to show the design of the dashboard; but, each section will discussed in depth for better understanding.

1. Availability Data

Figure 18 shows the first section in the Determination Dashboard. The information in this section is found in the WISE database. It lists the ship's hull number, the type availability, and the start and end date of the availability. Each ship is hyperlinked to the ship specific worksheet that contains the significance assessment and risk to maintenance assessment.

Availability Data			
Ship	Avail	Avail Start	Avail End

Figure 17. Availability Data Section of Dashboard

2. Significance Assessment

Figure 19 shows the areas that make up the significance assessment section of the dashboard. AD Impact Score, SUW Impact Score and the Non-Critical Weight are extracted from the significance assessment worksheet for each ship. The significance score is the average of the AD Impact Score and SUW Impact Score plus the Non-Critical Weight.

Significance Assessment			
AD Impact Score	SUW Impact Score	Non-Crit Weight	Significance Score

Figure 18. Significance Assessment Section of Dashboard

3. Risk Assessment

Figure 20 shows the areas that make up the risk assessment section of the dashboard

Risk Assessment									
Avail Length (Months)	Total Systems	Total Systems Changed	% Systems Changed	Last CSSQT	Delta (Years)	Operational Readiness Score	Maintenance Readiness Score	Safety Score	Risk Likelihood

Figure 19. Risk Assessment Section of Dashboard

Availability length is the number of months of the availability. Total Systems is a count of the number of combat/weapon systems onboard the ship. Total Systems Changed is number of systems that are being changed or added during the availability. Both inputs are calculated from the significance assessment and the percentage of systems changed is the total systems changed divided by the total systems. Last CSSQT is the previous year the ship conducted a CSSQT. The number of years that have elapsed since the last CSSQT and the end of the availability is the Delta. The next four areas of the risk assessment section are calculated from the previous sections and also use input from a separate worksheet.

Operational Readiness score is a function of Availability Length, Percentage of Systems Changed, and Delta. The function is designed to give more weight to the time elapse since the last CSSQT. This is accomplished by weighting the sum of the Delta and length of availability. If the Delta is greater than 13 years the Operational Readiness score will be dependent on the percentage of systems changed. So, if a large percentage of systems are being affected and the delta between CSSQTs is greater than 13 years, the likelihood of risk to operational readiness is greater. When the elapse between CSSQTs is less than 13 years the operational readiness risk likelihood is less. The formula used to determine the Operational Readiness score in an Excel spreadsheet is *MIN(10,LengthOfAvailabilty*0.25+Delta*0.75)*%SystemsChanged*. The formula is designed to ensure the score of Operational Readiness is less than or equal to 10. The next areas are the risk to Maintenance Readiness and Safety.

The risk to Maintenance Readiness Score comes from an assessment that is performed on the Significance Assessment worksheet. The details of the assessment procedure will be discussed in the next section. The Safety Score will be a 0, 5, or 10 based on the number of weapon systems being altered during the availability. This score is determined by the user and can be found by looking at the Significance Assessment to find which weapon systems are being modified. The Safety Score can also be a 10 if the Significance Assessment shows that a new weapon system is being installed on the ship that will require new ammunition handling and loading procedures. The final value in the Risk Assessment section is the overall Risk Likelihood. It is the average of the Operational Readiness, Maintenance Readiness and Safety scores.

B. SIGNIFICANCE ASSESSMENT AND RISK TO MAINTENANCE READINESS ASSESSMENT

Four values in the Determination Dashboard are determined on a separate worksheet within the spreadsheet that are specific to each ship being assessed. The significance assessment will calculate how significant the changes are to each warfare area and non-critical systems. The maintenance readiness assessment will calculate the likelihood of risk to maintenance.

1. Significance Assessment

NSWC PHD called this assessment the CSSQT Decision Tool Process. The review found areas of the process that needed improvement and the name is the first issue that needs to be addressed. The process is not making a decision; rather, it is assessing if the changes being made to the combat/weapon systems are significant. It is a minor change, but gives more clarity to the purpose of the process. The second issue found was the accuracy of the systems installed onboard each ship. There were numerous ships that had the wrong systems listed and/or systems were missing. This is easily addressed by double checking that systems input on the worksheet are the same systems listed on the WSID. The third issue was the mission area criticality and modernization type categories and subsequent weights which will be discussed next.

The review of the process found that systems that were not essential to a specific warfare area were not assessed even if the systems were being altered. All combat/weapon systems having any sort of modification need to be included in the assessment regardless of the importance to a warfare area. This issue is addressed by giving weight to non-critical systems. The modernization type categories did not have a category for systems not being changed which led to a spreadsheet that contained a number of blank cells and cells that contained FALSE as an entry. When a spreadsheet analysis has blank cells and FALSE cells, it looks incomplete. This is addressed by adding a sixth category to the modernization types. The new categories and weights used in the Significance Assessment are shown in Figure 21.

Modernization Type	Weight
Replace with New	1
Add Capability	1
Improve Capability	1
Improve Performance	0.5
Improve Infrastructures	0.25
No Change	0
Criticality	**Weight**
Critical	1
Necessary	0.75
Like to have	0.5
Non-Critical	0.25

Figure 20. Updated Categories and Weights

The final issue the review found with the process to determine if the changes are significant is the calculation of the significance value. As discussed in Chapter III, each system received a score by multiplying the mission criticality weight by the modernization type weight. The sum of all the systems scores yielded a total score for the warfare area. The process then would sum the warfare area criticality weights and divide the total score for the warfare area by this sum. This ratio was the value used to show how the changes impact each warfare area. The average of the warfare area scores would be the overall impact to the ship.

The methodology in Chapter III determines a better way to calculate if the changes are significant is to use only the sum of the system scores since this value takes into account both criticality and the type of modernization. Another problem with the calculation was it did not account for non-critical systems. The score for non-critical systems is calculated in the same manner as the score for a warfare area. The score for each warfare area and non-critical systems is used in the Determination Dashboard to calculate the overall significance of changes.

The assessment worksheet is large and a completed assessment is in Appendix D. Figure 22 shows a portion of the completed assessment.

System	Anti Air Defense	Mission Weight	Anti Surface Warfare	Mission Weight	Modernization	Weight
3D Volume Search Radar (SPS-48)	Necessary	0.75	Non-Critical	0.25	Improve Capability	1
2D Volume Search Radar (SPS-49)	Necessary	0.75	Non-Critical	0.25	No Change	0
Identification Friend or Foe (UPX-29)	Like to have	0.5	Like to have	0.5	No Change	0
High Fidelity Radar RADAR (SPQ-9B)	Critical	1	Critical	1	Improve Performance	0.5
Navigation Radar (SPS-73)	Non-Critical	0.25	Non-Critical	0.25	Improve Performance	0.5
Surface Search Radar (SPS-67)	Non-Critical	0.25	Critical	1	Improve Infrastructures	0.25
Navigation Data (WSN-7)	Necessary	0.75	Necessary	0.75	No Change	0
MK38 MGS	Non-Critical	0.25	Necessary	0.75	Replace with New	1

System	AD Impact Score	SUW Impact Score	Non-Critical Weight
3D Volume Search Radar (SPS-48)	0.75	0	0
2D Volume Search Radar (SPS-49)	0	0	0
Identification Friend or Foe (UPX-29)	0	0	0
High Fidelity Radar RADAR (SPQ-9B)	0.5	0.5	0
Navigation Radar (SPS-73)	0	0	0.125
Surface Search Radar (SPS-67)	0	0.25	0
Navigation Data (WSN-7)	0	0	0
MK38 MGS	0	0.75	0

Figure 21. Portion of Completed Significance Assessment

The ship used for the assessment in Figure 21 has 29 total combat/weapon systems onboard. The AD Impact Score, SUW Impact Score, and Non-Critical Weight columns are summed and this sum is the value used in the Determination Dashboard.

2. Risk to Maintenance Readiness

The methodology described in Chapter III determined the best method for assessing the risk to maintenance readiness is use a binary system. The first step is to create the assessment workspace. The logical place to conduct the assessment is on the same worksheet the Significance Assessment is conducted because the risk assessment is analyzing systems that are being modified during the availability. Each system that is being altered is copied from the list of systems in the Significance Assessment and listed in an area below the Significance Assessment. The second step is to label columns with the risk factors from the methodology. The risk factors are:

- Hardware Change
- Software Change

- PMS Impacted
- Technical Manuals Impacted
- Part Supply Impacted
- Training Impacted
- Certification Required
- Test Equipment Impacted
- Operating Sequencing System Impacted
- Detect-to-Engage Path Impacted

The third step is to collect all the SCDs applicable to the ship from the NDE. In most cases, when there is a software change and a hardware change on the same system, there will be two separate SCDs. The SCD sections from the methodology are reviewed and if the SCD indicates the change will impact a risk factor, the fourth step is to enter a 1 in the column. If it is not being affected, a zero is entered. The final step is to sum the values for each system to get a risk score for each system and then sum the risk scores to get an overall risk to maintenance readiness score which is used in the Determination Dashboard. Figure 23 shows a completed assessment (broken up for display purposes).

Impacted System	Hardware Change	Software Change	PMS Impacted	Tech Manuals Impacted	Part Supply Impacted	Training Impacted	Certifications Required	Test Equipment Impacted	Operating Sequence Systems Impacted	DTE Impacted	Sum
3D Volume Search Radar (SPS-48)	1	1	1	1	1	1	1	0	1	1	9
High Fidelity Radar RADAR (SPQ-9B)	0	1	0	1	0	1	1	0	0	1	5
Navigation Radar (SPS-73)	1	1	1	1	1	1	1	0	0	0	7
Surface Search Radar (SPS-67)	1	0	1	1	1	0	1	0	0	1	6
MK38 MGS	1	1	1	1	1	1	1	0	1	1	9
Critical Navigation Distribution (NCDS)	0	1	0	1	0	0	1	0	0	0	3
Command and Control (SSDS)	1	1	1	1	1	1	1	0	0	1	8
BFTT	0	1	0	1	0	1	1	0	0	0	4
TSSS	1	1	1	1	1	1	1	0	0	0	7
Electronic Signal Detection (SLQ-32)	1	1	1	1	1	1	1	0	1	1	9
Self Defense (RAM)	1	1	1	1	1	1	1	0	1	1	9
Point Defense (CIWS)	1	1	1	1	1	1	1	0	0	1	8
CDLMS	0	1	0	1	0	1	1	0	0	0	4
											6.77

Figure 22. Completed Risk to Maintenance Readiness Assessment

C. CSSQT DETERMINATION MATRIX

The final piece of the CSSQT Determination Dashboard is the Determination Matrix. When the all information is gathered and inputted for each ship, the final overall assessment for the fiscal year will look like Figure 24.

Availability Data				Significance Assessment			
Ship	Avail	Avail Start	Avail End	AD Impact Score	SUW Impact Score	Non-Crit Weight	Significance Score
CVN 68	PIA3	May-14	Feb-15	5.13	4.13	0.31	4.94
CVN 77	PIA1	Apr-15	Oct-15	5.63	3.88	0.69	5.44
LSD 42	SRA	Jan-15	Apr-15	1.00	1.00	0.00	1.00
LSD 44	PMA3-2	Sep-14	Jan-15	5.00	4.75	0.69	5.56
LSD 48	SRA	Aug-14	Nov-14	2.50	3.13	0.00	2.81
LSD 50	EDPMA	Jan-14	Jan-15	6.25	6.00	0.75	6.88
LSD 52	EDPMA	Feb-14	Feb-15	6.25	5.13	0.63	6.31
CVN 75	PIA2	Sep-14	Mar-15	5.50	3.00	1.25	5.50
CVN 76	PIA2	Oct-14	Apr-15	5.00	4.00	2.00	6.50
LHD 8	PMA1-2	Feb-15	Aug-15	3.75	3.50	0.13	3.75

Risk Assessment									
Avail Length (Months)	Total Systems	Total Systems Changed	% Systems Changed	Last CSSQT	Delta (Years)	Operational Readiness Score	Maintenance Readiness Score	Safety Score	Risk Likelihood
9.00	29	13	45%	2007	8	3.70	6.77	10	6.82
6.00	31	13	42%	2009	6	2.52	7.08	5	4.86
0.25	18	2	11%	1986	29	1.11	5.5	5	3.87
0.33	20	14	70%	1989	26	7.00	6.57	10	7.86
0.25	19	7	37%	1992	22	3.68	5.71	5	4.80
1.00	20	15	75%	1995	20	7.50	6.80	10	8.10
1.00	20	14	70%	1998	17	7.00	6.80	10	7.93
0.50	31	16	52%	2007	8	3.16	7.00	10	6.72
0.50	32	16	50%	2008	7	2.69	6.75	10	6.48
6.00	29	8	28%	2009	6	1.66	7.5	10	6.39

Figure 23. Completed FY15 CSSQT Determination Dashboard

The Significance Score and Risk Likelihood (highlighted with dark boxes) are the values plotted on the Determination Matrix chart shown in Figure 25.

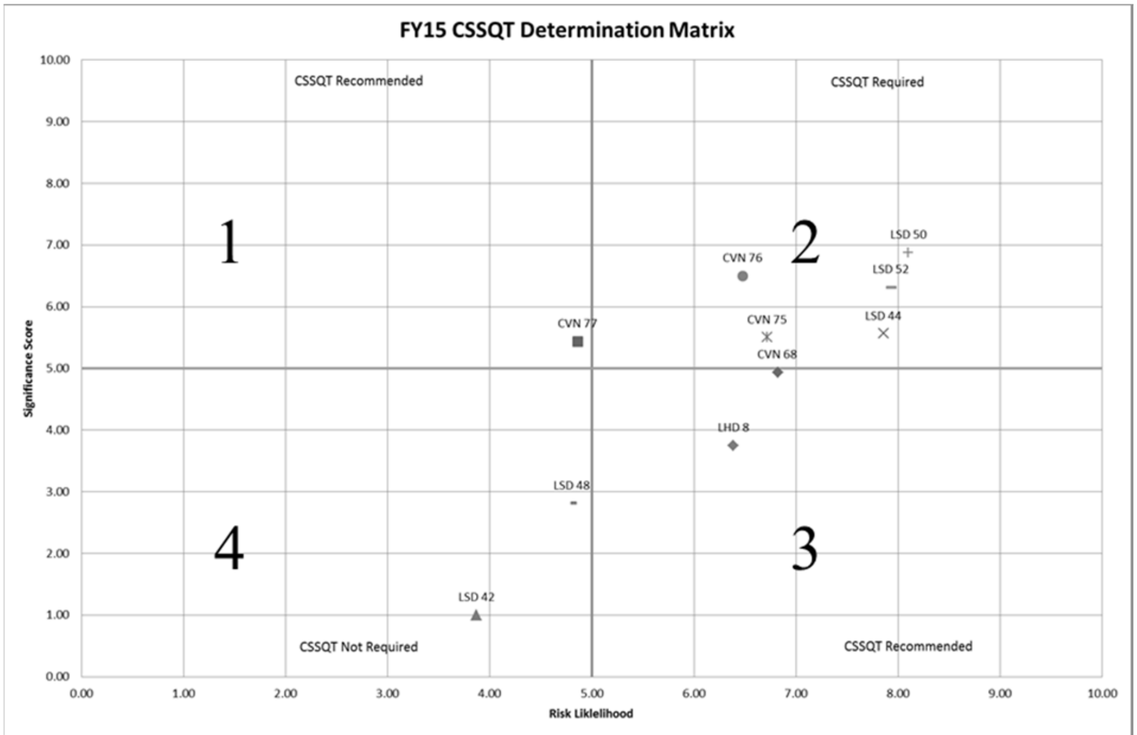

Figure 24. FY15 CSSQT Determination Matrix

The matrix is divided into four quadrants and each quadrant is labeled with a recommendation. If a ship is plotted in quadrant one a CSSQT is recommended because there are significant changes being made to the ship, but the likelihood that ship's readiness will be at risk is low. A ship in quadrant two has significant changes being made and the likelihood that the changes will impact ship's readiness is high; therefore, it is recommended that a CSSQT is required for that ship. In quadrant three the changes are not significant but the likelihood that the changes will impact ship readiness is high, so the ship is recommended to conduct a CSSQT. A ship in quadrant four does not have significant amount of changes and the changes have less likelihood to impact ship's readiness and it is recommended that a ship in the fourth quadrant does not conduct a CSSQT. Ships in quadrants one and four are recommended for CSSQT which means if funding and resources are available then these ships should be designated to perform a CSSQT. Ships in quadrant two would benefit the most from a CSSQT and it those ships should be the first to be allocated funding and resources.

This chapter used the methodology and the results of the review of current work discussed in Chapter III to develop a better way to assess the impact a maintenance availability has on a ship's readiness. The CSSQT Determination Dashboard was designed to put all the results of the assessment in a central location. The CSSQT Decision Tool process used by NSWC PHD was redesigned and the name was changed to Significance Assessment for clarity about the purpose of the tool. The risk assessment process was completely changed to align with NAVSEAINST 9093.1C and to remove subjective assessments. Finally, the Determination Matrix was introduced to graphically show the impact to ship's readiness. The next and final chapter will discuss conclusions and recommendations for further research.

V. CONCLUSION AND RECOMMENDATIONS

The purpose of this thesis is to develop a process to recommend ships for CSSQT by determining the impact an overhaul/modernization has on a ship's readiness. This was accomplished by analyzing a process used by NSWC PHD to recommend ships for CSSQT and determine if the process can be improved. The ultimate goal of the process is to determine the impact on a ship's readiness based on how significant the changes are and the likelihood the changes will impact readiness. The results of the process aid decision-makers in determining if a CSSQT is required for a ship post-availability. The thesis presented background information about CSSQT and the current process used by NSWC PHD. A majority of the work focused on a creating a methodology for reviewing the current process and an approach to correct issues discovered during the review. Finally, the work resulted in an assessment process that quantifies the impact a major overhaul/modernization has on a ship's readiness in a valid and objective way.

A. SUMMARY OF FINDINGS

The review of the current tools used by NSWC PHD was intended to investigate the processes used for flaws and issues. The analysis a determined that the method for determining significance was flawed for the following reasons:

- The name of tool does not accurately reflect the purpose of the tool
- There is an inaccurate accountability of all combat/weapon systems
- The significance calculation result is ambiguous
- The significance calculation does not account for non-critical systems
- A completed assessment can result in a spreadsheet that contains empty cells and cells that contain FALSE as an entry

The risk assessment review found the following issues with the proposed process:

- The risk areas do not align with the objectives outlined in NAVSEAINST 9093.1C
- Risk factors applied to more than one risk area which made the assessment complicated
- A large number of risk factors required subjective input from outside sources

- The output of the assessment was ambiguous

The byproducts of the review were a better understanding of the purpose of the assessment and a new methodology for conducting the assessment. The methodology determined the key to the assessment is the result has to be on a measurable scale. That is how ambiguity is removed from the output. By setting a scale and putting the result on that scale, there is more clarity in what the result means. The methodology used a 0 to 10 scale for both significance and risk likelihood. The higher the result of the assessment the more significant the changes are and the greater likelihood the changes will impact ship's readiness. Using the same scale for each assessment also allows the results to be plotted on a graph for better overall understanding and comparison with other ship being assessed.

The approach developed in this thesis is not perfect, but it does present a way to assess the impact a major overhaul/modernization will have on a ship. The assessment is completely quantitative and will yield dependable results when repeated for multiple ships. It also gives decision-makers a level of detail that does not overwhelm but enough to make a sound decision about moving forward or not in designating a ship for CSSQT.

B. RECOMMENDATIONS FOR FURTHER STUDY

Assessments that include risk are better when there is historical data available. The next logical step in for assessing the impact a maintenance availability is to collect data about the ship's performance post-availability. The data needs to include ships that conduct a CSSQT and those that do not to determine if there is a correlation between ship's readiness and the conduction of a CSSQT. There could be other correlations, such as length of availability and ship's readiness or number of systems changed and ship's readiness. The result would be thresholds that each ship could be compared to. For example, a ship that is conducting a 12 month availability and is having 75% of its combat/weapon systems altered should conduct a CSSQT because historical data shows that ships having these characteristics, and did not conduct a CSSQT, are more likely to be delayed in the training cycle. The research would require determining what data to collect and which metrics should be analyzed.

This research was only conducted on three classes of surface ships but CSSQT is conducted on all surface ships. The tool needs to be expanded to assess other classes of ships so there is a common process for designating all surface ship for CSSQT. This could be accomplished by enhancing the CSSQT Determination Process by using computer software that allows users to easily complete an assessment. Using a software program could allow users to select the ship class and it automatically generates an interface to input required information. The use of VBA is also a potential way to make the process simpler.

The final area that requires further research is the periodicity of CSSQT. CSSQT is a valuable evolutions that benefits both the crew and the ship. For some ships, a CSSQT is only conducted once in the entire life of the ship. An analysis of the importance of CSSQT should be conducted to determine if a CSSQT should be conducted on a more routine schedule.

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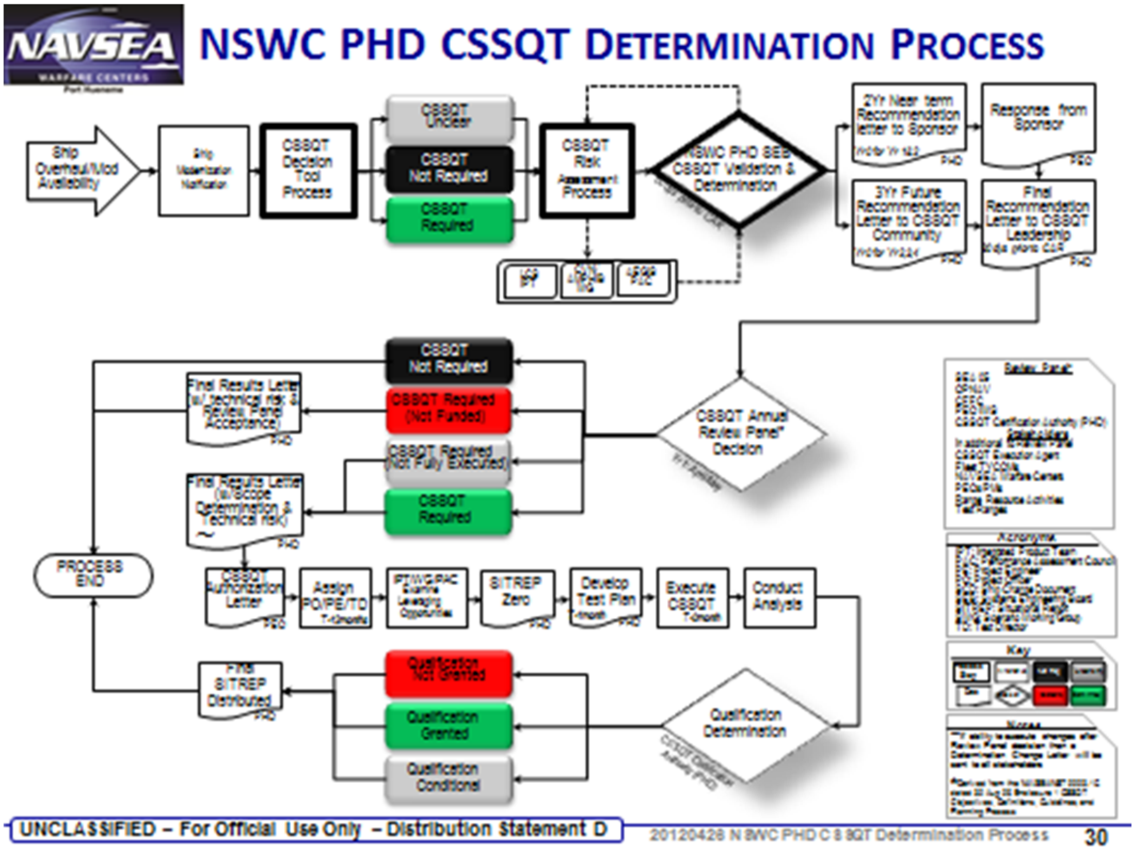
APPENDIX A


NAVSEA
NSWC PHD CSSQT DETERMINATION PROCESS
Ship Overhaul/Mod Availability
CSSQT Decision Tool Process
CSSQT Unclear
CSSQT Not Required
CSSQT Required
CSSQT Risk Assessment Process
NSWC PHD SEB CSSQT Validation & Determination
2Yr Near term Recommendation letter to Sponsor
Response from Sponsor
3Yr Future Recommendation Letter to CSSQT Community
Final Recommendation Letter to CSSQT Leadership
CSSQT Not Required
CSSQT Required (Not Funded)
CSSQT Required (Not Fully Executed)
CSSQT Required
CSSQT Annual Review Panel* Decision
Final Results Letter (w/ technical risk & Review Panel Acceptance)
Final Results Letter (w/Scope Determination & Technical risk)
PROCESS END
CSSQT Authorization Letter
Assign PO/PE/TD
SITREP Zero
Develop Test Plan
Execute CSSQT
Conduct Analysis
Qualification Not Granted
Qualification Granted
Qualification Conditional
Qualification Determination
Final SITREP Distributed
Review Panel
Acronyms
Key
Notes
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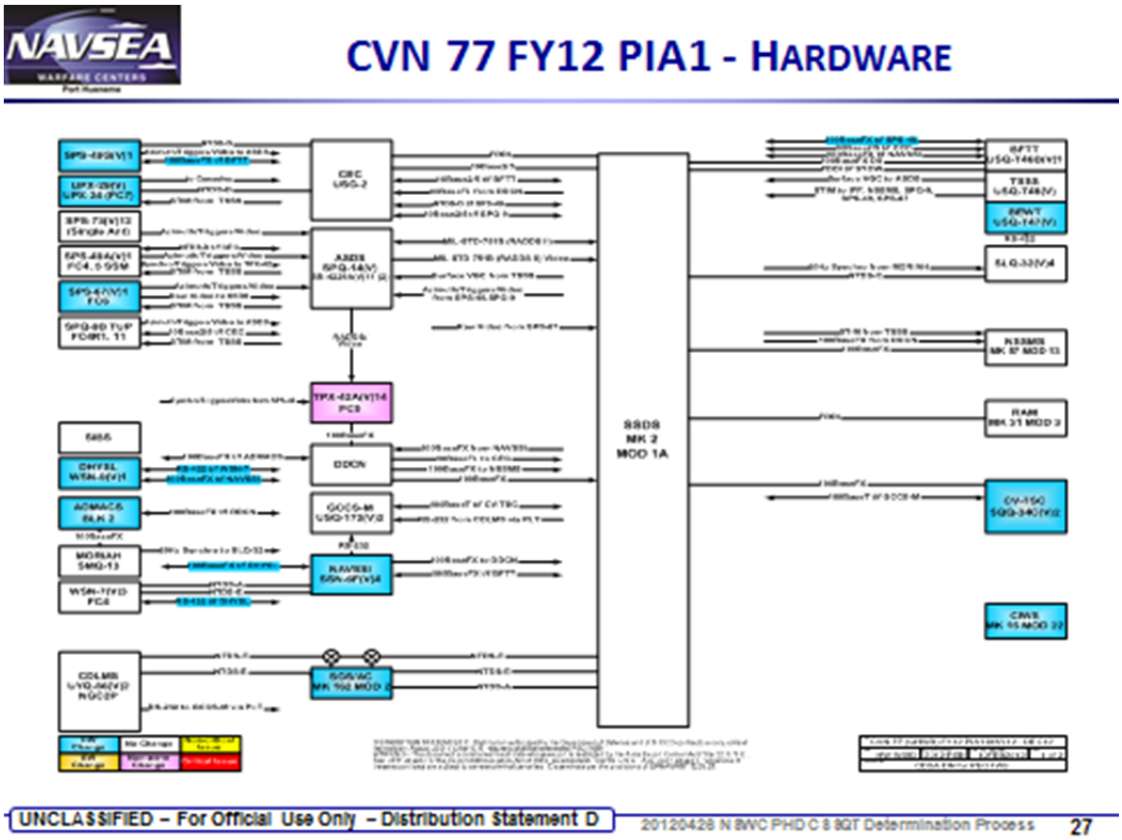
APPENDIX B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APPENDIX C

CVN 68					FY14 DPIA3			
System	**Anti Air Defense**	**Mission Weight**	**Anti Surface Warfare**	**Mission Weight**	**Modernization**	**Weight**	**AD Qualification Weight**	**SUW Qualification Weight**
3D Volume Search Radar (SPS-48)	Necessary	0.5	Unnecessary for Mission	0	Improve Performance	0.5	0.25	0
2D Volume Search Radar (SPS-49)	Necessary	0.5	Unnecessary for Mission	0		FALSE	0	0
Identification Friend or Foe (UPX-29)	Like to have	0.25	Like to have	0.25		FALSE	0	0
High Fidelity Radar RADAR (SPQ-9B)	Critical	1	Critical	1		FALSE	0	0
Navigation Radar (SPS-73)	Unnecessary for Mission	0	Unnecessary for Mission	0	Improve Performance	0.5	0	0
Surface Search Radar (SPS-67)	Unnecessary for Mission	0	Like to have	0.25		FALSE	0	0
Navigation Data (WSN-7)	Necessary	0.5	Necessary	0.5		FALSE	0	0
MORIAH	Unnecessary for Mission	0	Unnecessary for Mission	0		FALSE	0	0
ADMACS	Unnecessary for Mission	0	Unnecessary for Mission	0	Improve Performance	0.5	0	0
SIBS	Unnecessary for Mission	0	Unnecessary for Mission	0		FALSE	0	0
Track Correlation (CEC)	Critical	1	Critical	1		FALSE	0	0
Displays (ASDS)	Necessary	0.5	Necessary	0.5		FALSE	0	0
Air Traffic Control (TPX-42)	Unnecessary for Mission	0	Unnecessary for Mission	0		FALSE	0	0
Navigation Distribution (NAVSSI)	Necessary	0.5	Necessary	0.5		FALSE	0	0
Critical Navigation Distribution (NCDS)	Critical	1	Critical	1		FALSE	0	0
Command and Control (SSDS)	Critical	1	Critical	1	Improve Infrastructures	0.25	0.25	0.25
CV-TSC	Unnecessary for Mission	0	Unnecessary for Mission	0		FALSE	0	0
CDLS	Unnecessary for Mission	0	Unnecessary for Mission	0		FALSE	0	0
Training System (BFTT/TSSS/BEWT)	Unnecessary for Mission	0	Unnecessary for Mission	0	Replace with New	1	0	0
Electronic Signal Detection (SLQ-32)	Critical	1	Unnecessary for Mission	0	Improve Performance	0.5	0.5	0
Self Defense (RAM)	Critical	1	Unnecessary for Mission	0	Improve Capability	1	1	0
Self Defense (NSSMS)	Critical	1	Critical	1		FALSE	0	0
Point Defense (CIWS)	Critical	1	Critical	1		FALSE	0	0
Shipboard Network (ISNS)	Unnecessary for Mission	0	Unnecessary for Mission	0		FALSE	0	0
SGS/AC	Like to have	0.25	Like to have	0.25		FALSE	0	0
CDLMS	Like to have	0.25	Like to have	0.25	Improve Performance	0.5	0.125	0.125
		11.25		**8.50**			**2.13**	**0.38**
							18.89%	**4.41%**

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APPENDIX D

Ship:	USS Nimitz (CVN-68)				Avail:	FY14 DPIA3				
	Significance Assessment									
System	Anti Air Defense	Mission Weight	Anti Surface Warfare	Mission Weight	Modernization	Weight	AD Impact Score	SUW Impact Score	Non-Critical Weight	
3D Volume Search Radar (SPS-48)	Necessary	0.75	Non-Critical	0.25	Improve Capability	1	0.75	0	0	
2D Volume Search Radar (SPS-49)	Necessary	0.75	Non-Critical	0.25	No Change	0	0	0	0	
Identification Friend or Foe (UPX-29)	Like to have	0.5	Like to have	0.5	No Change	0	0	0	0	
High Fidelity Radar RADAR (SPQ-9B)	Critical	1	Critical	1	Improve Performance	0.5	0.5	0.5	0	
Navigation Radar (SPS-73)	Non-Critical	0.25	Non-Critical	0.25	Improve Performance	0.5	0	0	0.125	
Surface Search Radar (SPS-67)	Non-Critical	0.25	Critical	1	Improve Infrastructures	0.25	0	0.25	0	
Navigation Data (WSN-7)	Necessary	0.75	Necessary	0.75	No Change	0	0	0	0	
MK38 MGS	Non-Critical	0.25	Necessary	0.75	Replace with New	1	0	0.75	0	
MORIAH	Non-Critical	0.25	Non-Critical	0.25	No Change	0	0	0	0	
ADMACS	Non-Critical	0.25	Non-Critical	0.25	No Change	0	0	0	0	
SIBS	Non-Critical	0.25	Non-Critical	0.25	No Change	0	0	0	0	
Track Correlation (CEC)	Critical	1	Critical	1	No Change	0	0	0	0	
Displays (ASDS)	Necessary	0.75	Necessary	0.75	No Change	0	0	0	0	
Air Traffic Control (TPX-42)	Non-Critical	0.25	Non-Critical	0.25	No Change	0	0	0	0	
Navigation Distribution (NAVSSI)	Necessary	0.75	Necessary	0.75	No Change	0	0	0	0	
Critical Navigation Distribution (NCDS)	Critical	1	Critical	1	Improve Performance	0.5	0.5	0.5	0	
Command and Control (SSDS)	Critical	1	Critical	1	Improve Performance	0.5	0.5	0.5	0	
CV-TSC	Non-Critical	0.25	Non-Critical	0.25	No Change	0	0	0	0	
BFTT	Non-Critical	0.25	Non-Critical	0.25	Improve Performance	0.5	0	0	0.125	
TSSS	Non-Critical	0.25	Non-Critical	0.25	Improve Infrastructures	0.25	0	0	0.0625	
BEWT	Non-Critical	0.25	Non-Critical	0.25	No Change	0	0	0	0	
Electronic Signal Detection (SLQ-32)	Critical	1	Like to have	0.5	Improve Performance	0.5	0.5	0.25	0	
Self Defense (RAM)	Critical	1	Non-Critical	0.25	Improve Capability	1	1	0	0	
Self Defense (NSSMS)	Critical	1	Critical	1	No Change	0	0	0	0	
Point Defense (CIWS)	Critical	1	Critical	1	Improve Capability	1	1	1	0	
Shipboard Network (ISNS)	Non-Critical	0.25	Non-Critical	0.25	No Change	0	0	0	0	
SGS/AC	Like to have	0.5	Like to have	0.5	No Change	0	0	0	0	
USW-DSS	Non-Critical	0.25	Non-Critical	0.25	No Change	0	0	0	0	
CDLMS	Necessary	0.75	Necessary	0.75	Improve Performance	0.5	0.375	0.375	0	
							5.125	**4.125**	**0.313**	
Total Systems	29									
Systems Changed	13									
% Changed	45%									

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LIST OF REFERENCES

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Naval Sea Systems Command. 2006. *NAVSEAINST 9093.1C: Combat System Ship Qualification Trials for Surface Ships.* Washington, DC: Naval Sea Systems Command.

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